Population Estimate Survey of the Columbian Black-tailed Deer in Esquimalt, BC

Report Prepared for
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1 EXECUTIVE SUMMARY

Urban Columbian black-tailed deer have the potential to be a controversial topic among residents in a variety of communities. Management decisions need to be based on scientific evidence, including knowledge of the urban deer population density. This project aims to provide the Township of Esquimalt with an initial deer population estimate in collaboration with the Department of National Defence (DND), to help them with future urban deer management decisions.

The inventory method known as the mobile line technique was used and modified for the three habitat types in Esquimalt. The roads were surveyed while driving a car, the golf course path was surveyed while driving a golf cart, and the parks were surveyed while walking on the trails.

Four different data analysis models were applied to the data; two of these used statistical photo mark-recapture techniques, and the other two used recapture ratios. Based on the average of these four population estimates, the deer population in Esquimalt is estimated to be 100 deer. Those independent estimates ranged from 54 to 143 deer.

The 2016 Opinion Survey on deer divided Esquimalt into zones based on relative deer density, as concluded from the anecdotal public opinion survey results. The results from this scientific study were found to be quite similar. Parklands and the Gorge Vale Golf Course have a relatively high deer density; Rockheights and Esquimalt Village have a relatively medium deer density; and Gorge, Selkirk, and West Bay have a relatively low deer density.

In order to identify population trends, multi-year surveying is required. The exact methods used here should be replicated in future years in order to compare the data over time. If possible, Esquimalt and the DND should coordinate their methodologies so that more details can be matched between surveys in order to make the data more compatible.

2 ACKNOWLEGDEMENTS

The completion of this project would not have been possible without the generous help of:

- Bryan Gates, for your field assistance, photo identification expertise, and report feedback
- David Blundon, for your statistical analysis expertise
- Annette Dehalt, for your wildlife research expertise and report feedback
- Kevin Pons, for your field assistance and mapping expertise
- Kristy Kilpatrick, for your support and report feedback
- Support from the Urban Wildlife Stewardship Society's board members

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6 INTRODUCTION

A primary reason behind why there is so much debate surrounding the management of the Columbian black-tailed deer (CBTD) is that there is very little information known about their populations in various urban areas, including Esquimalt and surrounding Greater Victoria. CBTD management decisions need to be made on scientific evidence, including knowledge of the urban deer population density. This project aims to provide the Township of Esquimalt with an initial population estimate, gained in collaboration with the Department of National Defence (DND), to help with future CBTD management decisions.

7 BACKGROUND

7.1 ECOLOGY

History

In recent years, a few CBTD moved into Esquimalt and surrounding Greater Victoria, and have been reproducing there ever since. They thrive in urban areas because they are sheltered from natural predators and have a wider diversity of food than in the wilderness. They find food plentiful on the roadside edges and in gardens. An urbanized population would likely be unsuccessful surviving elsewhere in the wild (Bailey, Brown, & Sakuma, 2016). Studies have shown that the home ranges of urban deer are quite small, perhaps as small as 0.3 square km^2 for does, and 2.5 km^2 for bucks. However, bucks will move more during rut, and male groups may split up during the rutting season due to the dominance of one or more of the older bucks (Gates, pers. comm., 2017).

Life Cycle

The rutting season for CBTD is often late October to late November. At this time bucks will compete in order to breed with females. Fighting between males can be severe, resulting in broken antlers, scratches, puncture wounds and on rare occasions even death. It is at this time of year that deer are most active, and therefore most visible to count.

Bucks are capable of breeding as yearlings, but older, dominant bucks do most of the mating (Ministry of Environment, Lands and Parks, 2000). Bucks will follow does around for several days. Most bucks drop their antlers from January to March of each year; older bucks shed their antlers first. Bucks regrow their antlers from April through August each year, growing an inch every two days or so. Yearling CBTD almost always have unbranched “spike antlers”; 2-year-olds may have spikes, but may grow forked antlers with two or more branches. Multi-branched antlers are common on older bucks (Gates, pers. comm., 2017).

Fawns are born primarily from late May through June. Before giving birth, does will drive away their offspring from the previous year. More than 90% of all does will give birth every year (Ministry of Environment, Lands and Parks, 2000). However, a large majority of fawns die in their first year, and few CBTD live more than ten years. Most does don’t give birth until their second year, and don’t give birth to twins until at least their third or fourth birthday. The main causes of death are starvation, car accidents and hunting. Adults tend to be more cautious about crossing roads than young deer (Gates, pers. comm., 2017).

These deer are very urbanized, and therefore may have unpredictable behaviour, especially in comparison to a wild deer. They are constantly learning and adapting to their environment.

7.2 PREVIOUS STUDIES

2015 Oak Bay Driving Survey
This was a CRD survey conducted as the final part of the Regional Deer Management Strategy. This survey was conducted from October 23-November 13 2015 (Koning, 2016) using the mobile line technique. The Urban Wildlife Stewardship Society (UWSS) and Brian Nyberg (2016) suggested modifying this survey for Esquimalt.

2016 Winter DND Survey
DND conducted a deer survey from February 17-March 11 2016 as a pilot project for methodology testing using the mobile line technique. Since the survey was not completed during rutting season, it was difficult to identify individuals based on their antlers sizes and shapes (Crinkley, 2016). The density was estimated as 42 deer/km^2.

2016 Fall DND Survey
DND conducted a deer survey from November 3-23 2016 using the methods developed in the 2016 Winter DND survey. The density was estimated as 43 deer/km^2 (Prentiss, 2017).

2016 Fall Esquimalt Opinion Survey
The response from this survey recommended that a population estimate should be conducted, in order to make management decisions (Nyberg, 2016). Funding for education also came out of this report.

2017 Fall DND Survey
This present project was coordinated with this DND survey. Using the mobile line technique, the density on the DND lands was estimated as 41 deer/km^2 (Prentiss, 2017).

8 PROJECT RATIONALE

The 2016 Opinion Survey showed that the citizens of Esquimalt have mixed feelings about the presence of CBTD in their community (Nyberg, 2016). Some love having wildlife around, while others consider the deer a nuisance, due to damage to some garden plants and vehicle-deer accidents. (ICBC deer collision statistics are given in Appendix D). The 2016 Opinion Survey recommended that a population estimate should be conducted in order to help make management decisions, rather than just basing decisions on complaints.

This project selects and standardizes survey methods, in hopes that future surveys will be conducted with these same standardized methods in order to more accurately determine long term population trends, both within Esquimalt and in the surrounding areas.

9 OBJECTIVES

1. Determine the population size of Columbian black-tailed deer in Esquimalt.
2. Compare the deer densities within the zones of Esquimalt to the opinions about deer densities of the residents of those sections, as determined by the 2016 Opinion Survey report by Brian Nyberg.

10 SITE DESCRIPTION

Esquimalt

The Township of Esquimalt encompasses 7.08 km^2, including the 1.59 km^2 of land administered by the DND. This leaves 5.49 km^2 of a study site to be surveyed. Esquimalt is composed of residential areas, industrial areas, small parks, and a golf course. The small area of Esquimalt is somewhat enclosed by geographic features, primarily ocean shoreline, which restrict deer movement in certain directions.

For the purpose of surveying, Esquimalt has been divided into seven different zones:

Rockheights

Rockheights is primarily a residential area, and has one park called High Rock Park.

<u>High Rock Park</u>

Figure 1. Kevin Pons taking field notes at High Rock Park

Figure 2. View from the top of High Rock Park

Figure 3. Trail at High Rock Park

Esquimalt Village

Esquimalt Village is primarily a residential area. The houses are very close together. This zone has two parks, Macaulay Point Park and Saxe Point Park.

Macaulay Point Park

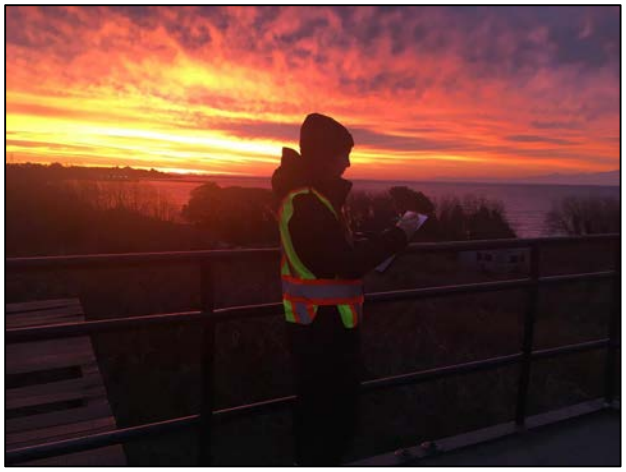

Figure 4. Megan Sakuma taking field notes while enjoying the beautiful sunrise at Macaulay Point Park

Figure 5. The view from Macaulay Point Park

Figure 6. Kevin Pons surveying at Macaulay Point Park

Saxe Point Park

Figure 7. The ocean view from Saxe Point Park

Figure 8. The forested trail at Saxe Point Park

Parklands
Parklands is primarily a residential area, and has houses with larger properties.

Gorge
Gorge is primarily a residential area, and is bound by the ocean and a main road. It has one park, Gorge Park.

Gorge Park

Figure 9. The playground at Gorge Park

Figure 10. Deer trails at Gorge Park

Figure 11. The trail at Gorge Park

Figure 12. Gorge Park

Selkirk
Selkirk is primarily a residential area, and is bound by the ocean and a main road.

West Bay
West Bay is primarily an industrial area.

Golf Course

The Gorge Vale Golf Course is the largest green space in Esquimalt with 140 acres. It is home to a variety of wildlife, including deer, rabbits, squirrels, racoons, and birds. The staff have stated that they often see deer on the course, and believe the deer use the course as a refuge, as there are prime untouched wooded areas there, and golfers don't bother them. (However, the golfers aren't as fond of the geese. The course has two trained dogs that chase away the geese).

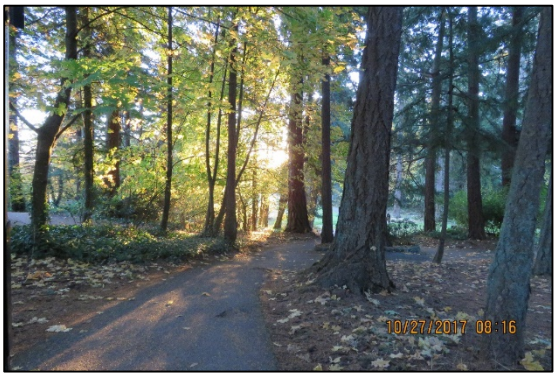

Figure 13. The golf cart path at the Gorge Vale Golf Course

Figure 14. The greens at the Gorge Vale Golf Course

Figure 15. Kevin Pons surveying in the golf cart

Figure 16. Deer trails at the Gorge Vale Golf Course

11 METHODS

To ensure the most appropriate method was chosen for this project, extensive background research was conducted. First, previous deer studies in the area were reviewed from Bailey, Brown, & Sakuma (2016), Cote, Prince & Windeback (2014), Crinkley (2016), Koning (2016), Nyberg (2016), and the Urban Wildlife Stewardship Society, District of Oak Bay (n.d.).

In addition, a literature review was conducted. Insights from Amos, Baxter, Finch, Lisle, & Murray (2014), Cederlund *et. al* (1998), Ministry of Environment, Lands and Parks (1998), Radford University (n.d.), and Schult and Armstrong (1999) were particularly useful.

Lastly, many personal communications were conducted. Important contributors were:

- Bryan Gates (R.P.Bio (Ret) and former UWSS President)
- David Blundon (Camosun College Statistics Instructor)
- Annette Dehalt (UWSS Vice President and Camosun College Wildlife Biology Instructor)
- Kevin Pons (Field Assistant and Camosun College Environmental Technology student)
- Kristy Kilpatrick (UWSS President)
- Steve Huxter (UWSS board member and Project Manager for an Oak Bay/Province of BC study)
- Tracy Cornforth (DND)
- Jaclyn Prentiss (DND)
- Billy Wilton (Provincial Wildlife Biologist)

11.1 Survey Route Design and Sample Protocols

Surveying was conducted during the rutting season. This was because deer are most active during this time of year, and bucks still have their antlers which makes them easier to identify (Gates, pers. comm., 2017). The window of time in which the sampling was completed was within Oct. 23 – Nov. 30, 2017. Surveys were conducted on Monday-Friday for the first 3 weeks of the window, to allow a buffer if the sample days needed to be pushed back due to unpredictable factors such as weather. In addition, keeping the sample days in a shorter time frame allowed for more consistency with outside factors such as weather and traffic.

Combining some of the 7 zones, the study site was split into five different sections, in order to shorten the survey time to concentrate the sampling at the peak active hours at dawn and dusk. These five sections were based on the zones assigned by Nyberg (2016). Refer to Appendix A for his map.

1. Rockheights roads and Highrock Park
2. Esquimalt Village roads, Macaulay Point Park, and Saxe Point Park
3. Parklands roads, Gorge roads, and Gorge Park
4. Selkirk roads, West Bay roads
5. Gorge Vale Golf Course

Figure 17 shows an overview of all of the survey routes. Refer to Appendix G to see an enlarged version of each zone for more clarity.

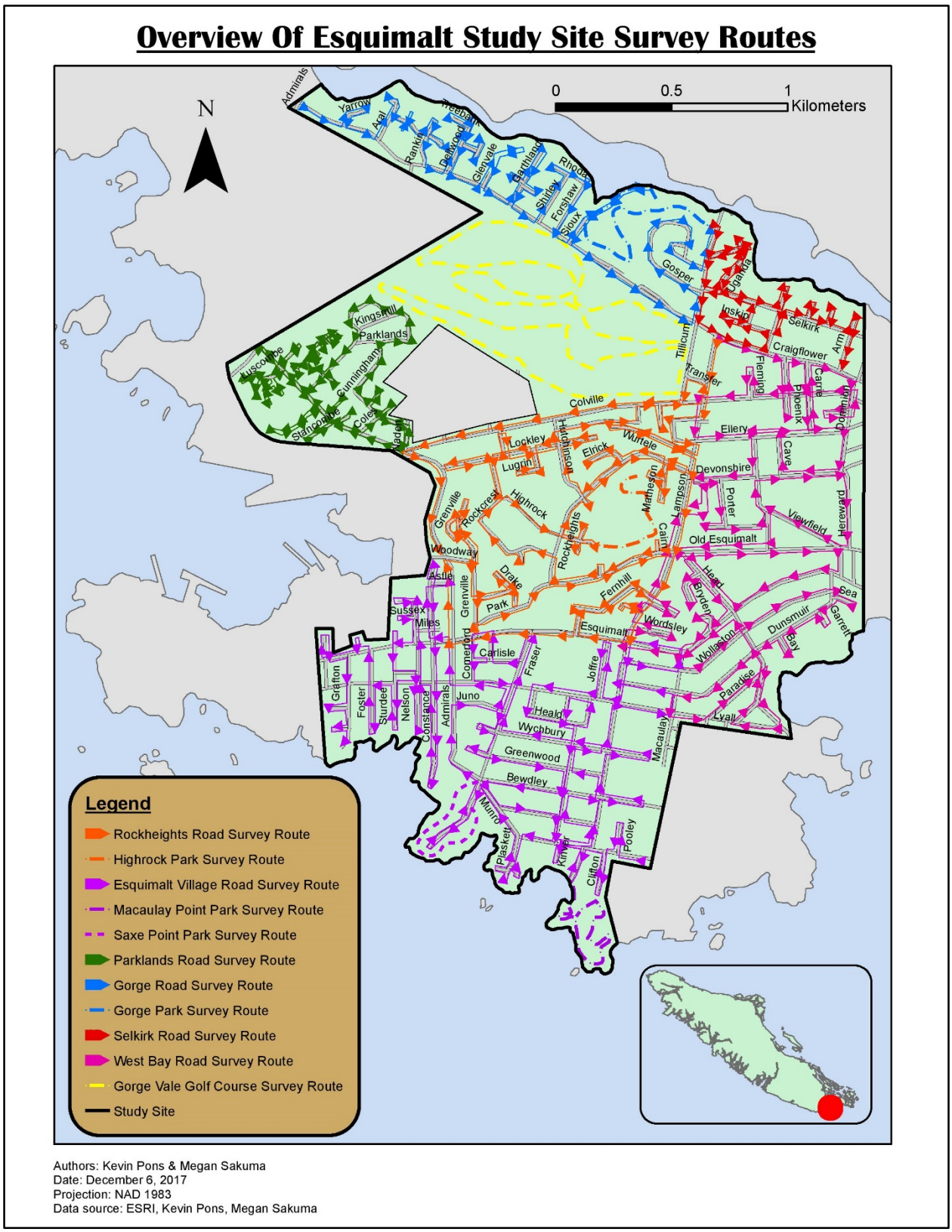

Figure 17. Map of Overview of Esquimalt Study Site Survey Routes

Each zone was surveyed for approximately one to two hours at both dawn and dusk on each sampling day. The surveys were repeated in the same order three times over the course of three weeks. This resulted in 15 sample days, sampling twice a day, for a total of 30 samples. The direction of the survey route was reversed on alternate days to allow each zone to be surveyed during the peak active hours of dawn/dusk. For a detailed schedule of the surveys, refer to Appendix E.

This project was coordinated with DND to conduct our respective surveys on the same days. When possible, we started our survey routes at the same place and time, at points of access for deer along our boundaries, and then fanned out from there. This reduced double counting of deer.

The mobile line technique (Krebs, 2014) was used to survey the deer, and was slightly modified to adapt to the road, golf cart path, or trail. For the road zones, all roads were driven. For the golf course, all of the golf cart paths were driven. For the parks, a short trail that stuck to the main trail and covered the majority of the area was walked. Only the four large parks were surveyed, due to lack of time. By selecting the most easily accessible routes to survey in each of the three habitat types, this provided consistency amongst them.

Figure 18. Megan Sakuma surveying in the golf cart

Figure 19. Megan Sakuma surveying in the car with a sign on the back

Surveying in a team of at least two people was required for both safety and quality data collection. For the road surveys, a speed of 15 km/hr was aimed to be maintained. The passenger directed the driver where to turn, using the survey route maps and tracked their location using google maps on a smartphone. When a deer was sighted, the vehicle/golf cart/personnel pulled over to the side of the road/path/trail. Due to the many dead-end roads in Esquimalt, the driving survey routes required lots of turning around and doubling back on roads. Doubling back on a road was not regarded as part of the survey, and therefore any deer spotted on the way back were not counted. The following data was collected: Photos, GPS coordinates, distance and angle measurements, time/date, and the gender/age of deer seen. Refer to Appendix B for DND's handy guide for determining gender/age. Refer to Appendix F for the data sheet.

Figure 20. The survey equipment list

Figure 21. Megan Sakuma taking pictures of deer from the car

12 RESULTS

12.1 Data Collection

During the 6 samples taken in 7 zones over 30 sampling times, 85 deer were sighted. Table 1 shows the raw data collected in each sample in each zone. Figures 22 and 23 represent this data in graph form. The increased sightings in Week 2 might be due to peak rutting season.

Sample	Rock-heights	Esquimalt Village	Parklands	Gorge	Selkirk	West Bay	Golf Course	Total
Week 1 Dawn	2	3	3	0	1	0	1	**10**
Week 1 Dusk	5	5	1	0	0	0	0	**11**
Week 2 Dawn	0	5	8	0	0	2	2	**17**
Week 2 Dusk	6	5	2	0	0	0	6	**19**
Week 3 Dawn	1	4	5	0	0	0	3	**13**
Week 3 Dusk	2	4	0	0	0	0	9	**15**
Total	**16**	**26**	**19**	**0**	**1**	**2**	**21**	**85**

Table 1. Number of deer sightings for each sample in each zone

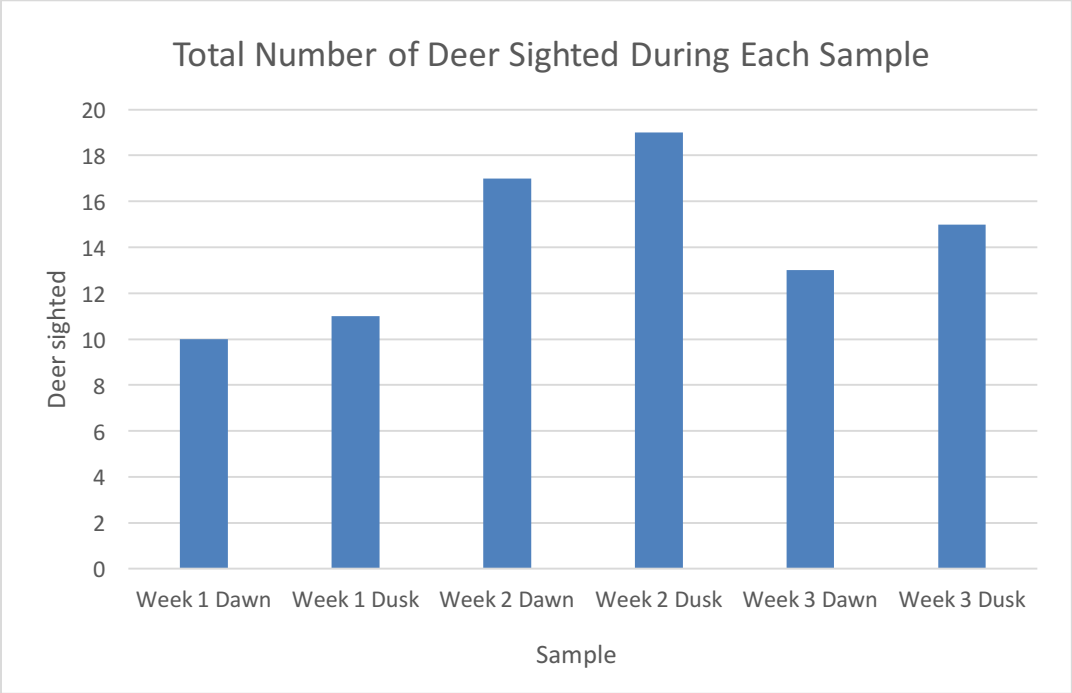

Figure 22. Graph of total number of deer sighted during each sample

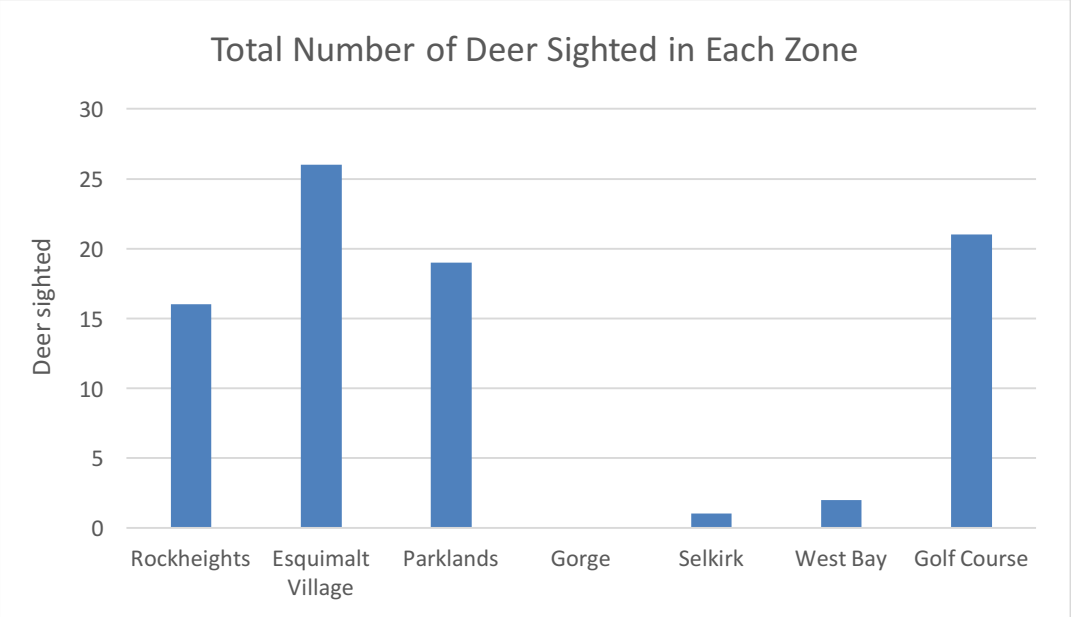

Figure 23. Graph of total number of deer sighted in each zone

Figure 24 shows the spatial distribution of all of the 85 deer sightings over the 6 samples. Figure 25 shows a density map created based on these data points. The red represents area with a high number of sightings; the yellow represents areas with a medium number of sightings; and the blue represents areas with a low number of sightings.

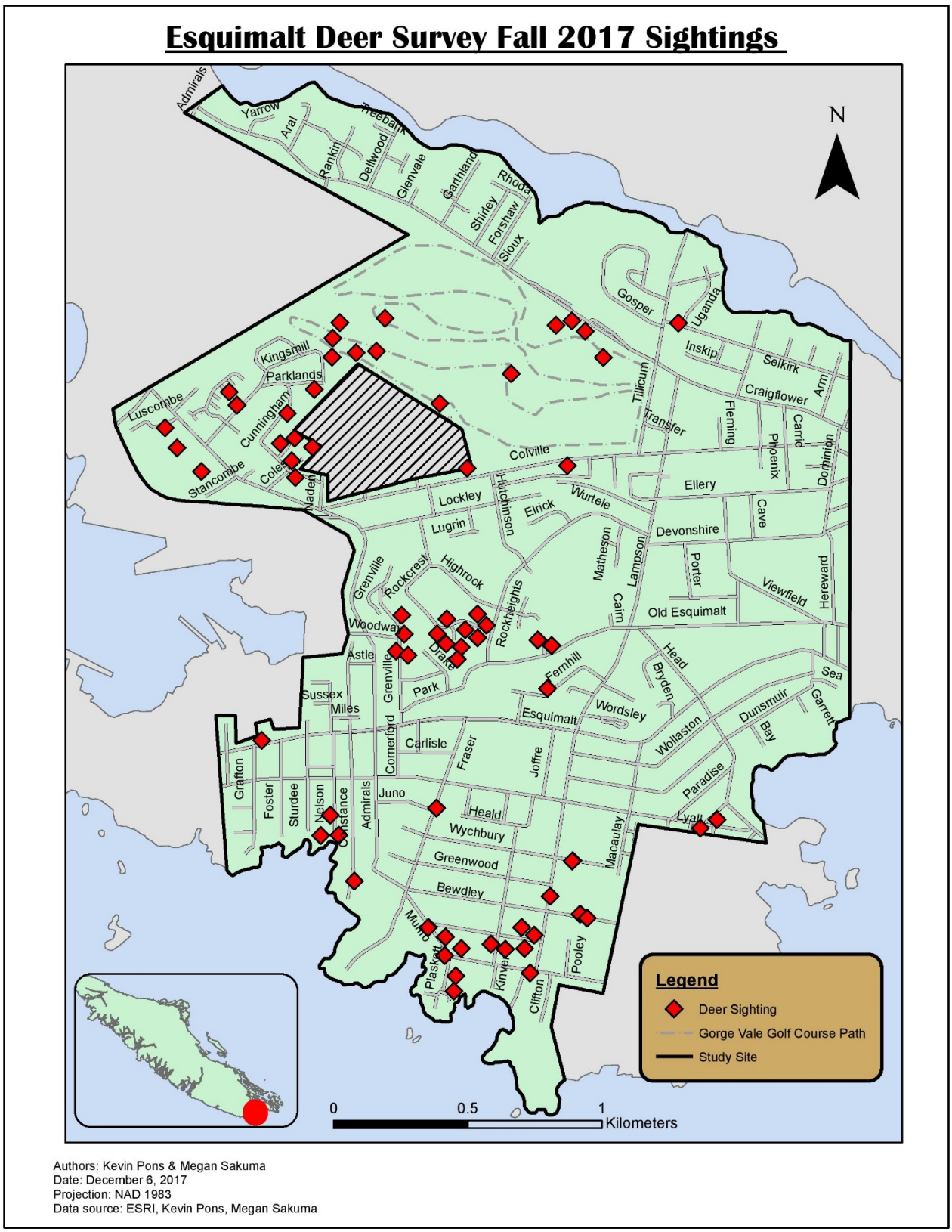

Figure 24. Map of Esquimalt Deer Survey Fall 2017 Sightings

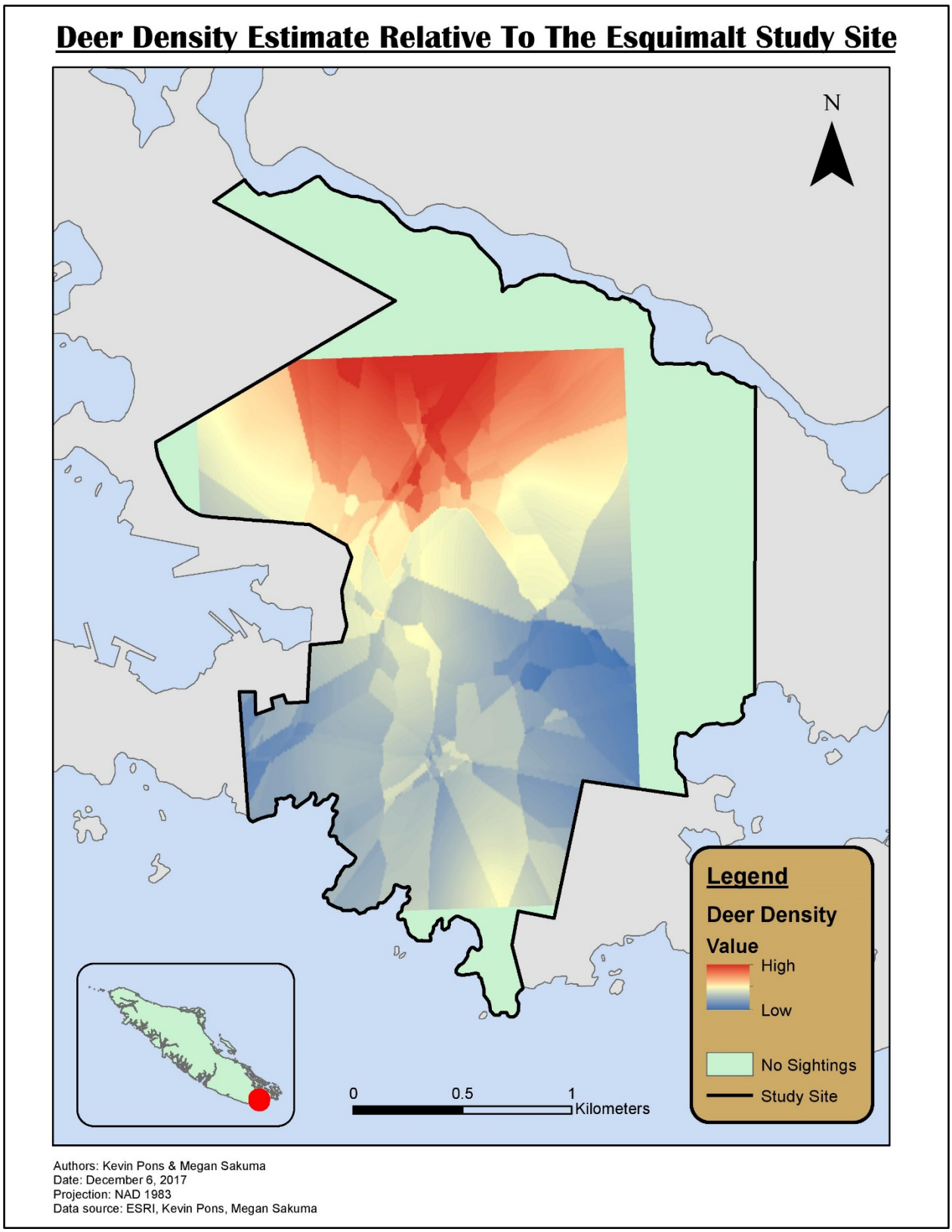

Figure 25. Map of deer density estimate relative to the Esquimalt Study Site

12.2 Herd Composition

Each deer sighted was placed into a category of either buck, doe, or fawn. For the purpose of this project, a fawn was considered a deer that had been born spring of 2017. Anything older than that was considered to be a mature adult, and was placed in either the buck or doe category.

Table 2 shows total deer sightings along all survey routes by gender and age. Herd composition is determined by the ratio between the number of bucks and does, and by the ratio of the number of fawns and does within the population. Within the study area it was found that:

For every 1 doe, there are 0.73 bucks.
Doe:buck = 33:24 = 1:0.73

For every 1 doe, there are 0.85 fawns.
Doe:fawn = 33:28 = 1:0.85

The ratio of less than one fawn per doe by November is not surprising, given the normal high mortality of newborn fawns, especially within crowded urban areas.

Herd Composition								
	Rock-heights	**Esquimalt Village**	**Parklands**	**Gorge**	**Selkirk**	**West Bay**	**Golf Course**	**Total**
Bucks	5	9	3	0	0	1	6	24
Does	9	8	7	0	1	1	7	33
Fawns	2	9	9	0	0	0	8	28
Total	16	26	19	0	1	2	21	85
Doe:buck	1:0.56	1:1.13	1:0.43	n/a	n/a	1:1	1:0.86	**1:0.73**
Doe:fawn	1:0.22	1:1.13	1:1.29	n/a	n/a	n/a	1:1.14	**1:0.85**

Table 2. Herd Composition in Esquimalt Fall 2017

12.3 Fourier Series Estimator

This analysis was unsuccessful. Analysis was able to be completed on only 2 out of 6 samples, and the results were unreasonably low as shown in Table 3. The cause cannot be explained. These results will be omitted as they will skew the overall population estimate results.

Sample	**Population Estimate**	**Lower 95% confidence limit**	**Upper 95% confidence limit**
Week 1 Dawn	n/a	n/a	n/a
Week 1 Dusk	21	-4	45
Week 2 Dawn	19	-10	47
Week 2 Dusk	n/a	n/a	n/a
Week 3 Dawn	n/a	n/a	n/a
Week 3 Dusk	n/a	n/a	n/a
Average	20	-7	46

Table 3. Fourier series population estimate for each sample

12.4 PHOTO IDENTIFICATION

One way to estimate the size of a population is to capture and mark individuals from the population, and then to re-sample to see what fraction of individuals carry marks. This is called the mark recapture technique. In this survey, photos were taken of each deer sighted to "mark" them. Two models were applied to determine the absolute population estimate, using photo identification. The results from each model were compared, to ensure quality control. They both required very similar data collection.

"When trying to get photos of the deer, there are ideal ways to photograph them in order to ensure the highest amount of success when attempting to identify individuals later on… While the antlers are an obvious and easy way to identify an animal, ideally there will be some notable or distinguishing features somewhere on the body as well. These features will allow for the identification of the animal in future years, even after the current set of antlers have been shed… It should be noted that although these methods are ideal, in real life scenarios it is frequently difficult to get any or all of them to happen" (Bailey *et. al*, 2016, p.36).

Ideal criteria:

1. "Face and antlers facing forwards.
    a. This allows for potential identification of important facial features or distinctions, as well as noting antler size and shape.
2. Ears flared outwards facing forwards.
    a. Not only are the antlers and face important, but ears can also frequently exhibit specific colours or patterns, as well as small nicks or deformities that can be used for identification purposes.
3. Full body in the image.
    a. This is another important one, as it will show any distinguishing features along the length of the body or legs.
4. Multiple angles.
    a. Multiple angles of every fund deer strongly recommended, as it allows for the largest possibility of catching different markings on different sides of the deer."

(Bailey *et. Al*, 2016).

To see the photo identification catalogue developed, refer to Appendix I.

12.5 SCHNABEL METHOD

The Schnabel method is a variation of the Mark Recapture technique. Krebs (2014) explains that "In the Schnabel method, individuals caught at each sample are first examined for marks, then marked and released. Marking occurs in each of the sampling times. Only a single type of mark need be used, since throughout a Schnabel experiment we need to distinguish only two types of individuals: marked = caught in one or more prior samples; and unmarked = never caught before" (p.41).

"Assumptions:

1. The population is closed, so that N is constant.
2. All animals have the same chance of getting caught in the first sample.
3. Marking individuals does not affect their catchability.
4. Animals do not lose marks between the two sampling periods.
5. All marks are reported upon discovery in the second sample."

(Krebs, 2014, p.38).

$$Population\ Estimate = \widehat{N} = \frac{\sum_t (C_t M_t)}{\sum_t R_t}$$

$C_t = total\ number\ of\ individuals\ caught\ in\ sample\ t$
$M_t = number\ of\ marked\ individuals\ in\ the\ population\ just\ before\ the\ t-th\ sample\ is\ taken$
$R_t = number\ of\ indivuals\ already\ marked\ when\ caught\ in\ sample\ t$

The data for the bucks was arranged into this table:

	Number of deer caught (C_t)	Number of recaptures (R_t)	Number newly marked (less deaths)	Marked deer at large (M_t)
Week 1 Dawn	3	0	3	0
Week 1 Dusk	5	1	4	3
Week 2 Dawn	3	1	2	7
Week 2 Dusk	5	0	5	9
Week 3 Dawn	4	3	1	14
Week 3 Dusk	4	0	n/a	15
	24	**5**	**15**	**48**

Table 4. Data for Schnabel population estimate method

$$\widehat{N} = \frac{197}{5} = \mathbf{39\ bucks}$$

A 95% confidence interval for this estimate is obtained from the Poisson distribution because there are less than 50 recaptures. Obtained from a table, with $\sum R_t = 5$ recaptures, the 95% confidence limits on $\sum R_t$ are 1.970 and 11.177.

$$Upper\ 95\%\ Confidence\ Limit = \frac{\sum (C_t M_t)}{\sum R_t}$$

$$= \frac{197}{1.970} = 100\ bucks$$

$$Lower\ 95\%\ Confidence\ Limit = \frac{\sum (C_t M_t)}{\sum R_t}$$

$$= \frac{197}{11.177} = 17.63\ bucks$$

As calculated by the Schnabel method, the 95% confidence limits are 18 to 100 bucks.

Although all of the bucks were able to be individually identified, the does and fawns were not. Without antlers, it is much more challenging to identify unique features. Some does and fawns were able to be uniquely identified, but in order to run the statistical model, all does and fawn had to be uniquely identified.

Using the ratio of the buck population estimate to the buck sightings (39/24 = 1.56), the doe and fawn sightings were multiplied up for a total population estimate of **135 deer**.

	Sightings	Percentage	Estimate
Bucks	24	28%	39 (1.56x)
Does	33	38%	52
Fawns	28	33%	44
Total	85	100%	135

Table 5. Using ratios to multiply up for a total population estimate of the Schnabel method

The ratio of the total population estimate to the population estimate of the bucks was used to estimate the 95% confidence intervals for the total population estimate:

$$\frac{135}{39} = 3.4615$$

	Bucks	All deer
Lower confidence limit	18	62 (x3.4615)
Population estimate	39	135
Upper confidence limit	100	346

Table 6. Using ratios to multiply up for confidence limits for the Schnabel metho

12.6 Null Model

The Null Model is another variation of the Mark Recapture technique. It uses the maximum likelihood method to find the most likely population estimate size (Krebs, 2014).

"Assumptions:

1. The population is closed, so that N is constant.
2. All animals have the same chance of getting caught in the first sample.
3. Marking individuals does not affect their catchability.
4. Animals do not lose marks between the two sampling periods.
5. All marks are reported upon discovery in the second sample."

(Krebs, 2014, p.38).

This equation is solved by trial and error using a provisional range of estimates of population size.

$$L(\hat{N}_0, \hat{p}|X) = \ln\left(\frac{N!}{(N-M)!}\right) + (n)\ln(n) + (tN-n)\ln(tN-n) - (tN)\ln(tN)$$

$\hat{N}_0 = estimated\ population\ size\ from\ the\ null\ model\ of\ CAPTURE$
$N = provisional\ estimate\ of\ population\ size$
$\hat{p} = probability\ of\ capture$
$M = total\ number\ of\ different\ individuals\ captured\ in\ the\ entire\ sampling\ period$
$n = total\ number\ of\ captures\ during\ the\ entire\ sampling\ period$
$t = total\ number\ of\ sample\ days\ (e.g.\ days)$
$ln = natural\ log\ (log_e)$
$L = log\ likelihood\ of\ the\ estimated\ value\ \hat{N}_0\ and\ p, given\ the\ observed\ data$

Values from 0-100 were tested for *N* into the equation using Excel. Here is one example that used 40 for *N*:

$$L(\hat{N}_0, \hat{p}|X) = \ln\left(\frac{40!}{(40-19)!}\right) + (24)\ln(24) + (6(40)-24)\ln(6(40)-24) - \big(6(40)\big)\ln(6(40))$$
$$= -13.08$$

This graph represents the results of the repeated calculation for the values 31-54 as N:

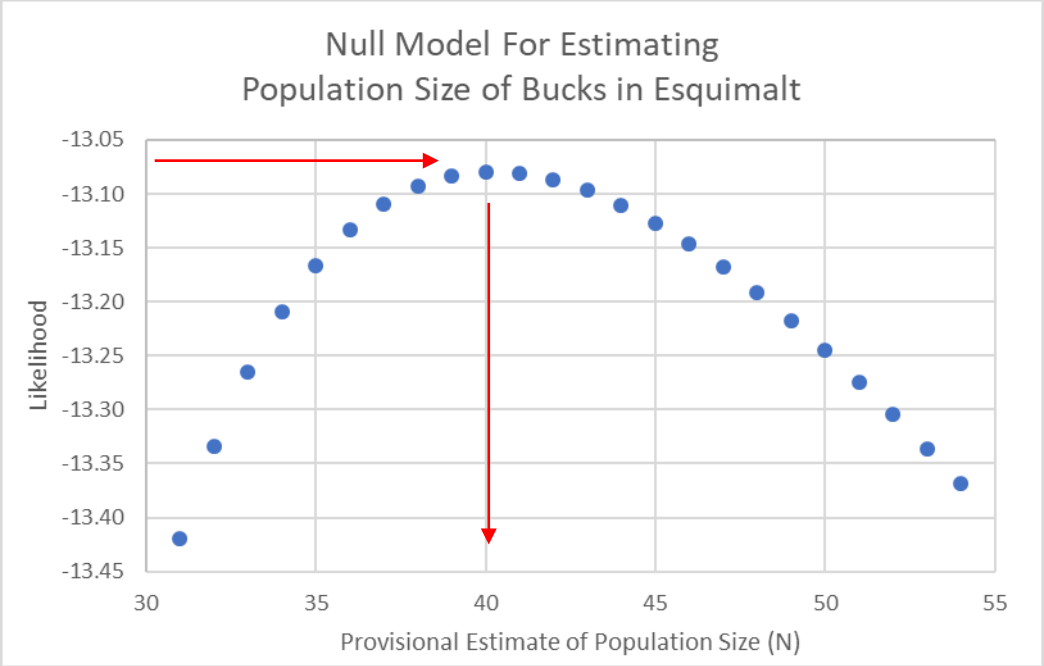

Figure 26. Graph of the null model for estimating population size of bucks

The graph shows that the maximum likelihood of the population size is 40.

Next, the probability of an individual buck being sighted at any given sample period can be determined from the equation:

$$\hat{p} = \frac{n}{t\widehat{N}_0} = \frac{24}{6\ (40)} = 0.10$$

Given this probability we can now estimate the variance from the equation:

$$\widehat{Var}(\widehat{N}_0) = \frac{\widehat{N}_0}{(1-\hat{p})^{-t} - \left(\frac{t}{1-\hat{p}}\right) + t - 1}$$

$$\widehat{Var}(\widehat{N}_0) = \frac{40}{(1-0.10)^{-6} - \left(\frac{6}{1-0.10}\right) + 6 - 1} = 186.04$$

The resulting 95% confidence interval can be calculated from the equation (where z_α = standard normal deviate):

$$95\%\ confidence\ intervals = \widehat{N}_0 \pm z_a\sqrt{\widehat{Var}(\widehat{N}_0)}$$

$$\widehat{N}_0 \pm 1.960\sqrt{186.0381}$$

$$\mathbf{40 \pm 27\ bucks}$$

There are 40±27 bucks in Esquimalt with 95% confidence intervals.

Using the ratio of the buck population estimate to the buck sightings (40/24 = 1.67), the doe and fawn sightings were multiplied up for a total population estimate of **143 deer**.

	Sightings	**Percentage**	**Estimate**
Bucks	24	28%	40 (1.67x)
Does	33	38%	55
Fawns	28	33%	47
Total	85	100%	143

Table 7. Using ratios to multiply up for the population estimate using the Null Model

The ratio of the total population estimate to the population estimate of the bucks was used to estimate the 95% confidence intervals for the total population estimate:

$$\frac{143}{40} = 3.575$$

	Bucks	Total deer
Lower confidence limit	13	47 (x3.58)
Population estimate	40	143
Upper confidence limit	67	240

Table 8. Using ratios to multiply up for the confidence limits for the Null Model

12.7 Joint Hypergeometric Maximum Likelihood Estimator

This analysis was unable to be completed because there was not enough time to build up a significant photo ID catalogue of bucks before the surveys began, which was a requirement for this model.

12.8 Recapture Ratios

12.8.1 Ratio 1

Over the entire sampling period, 19 individual bucks were marked, and 5 of those were "recaptured". Using this ratio, we can determine that for every 1 deer sighted, there are 3.80 more deer hiding that can not be seen. This ratio was multiplied up for each sample, resulting in an average estimate of **54 deer** in Esquimalt**.**

$$\frac{19\ individual\ bucks}{5\ recaptured\ bucks} = 3.80$$

Sample	Deer Sighted	Population Estimate
Week 1 Dawn	10	38.00 (x3.80)
Week 1 Dusk	11	41.80
Week 2 Dawn	17	64.60
Week 2 Dusk	19	72.20
Week 3 Dawn	13	49.40
Week 3 Dusk	15	57.00
Average	14.17	**53.83**

Table 9. Population estimate of each sample using Ratio 1

12.8.2 Ratio 2

Out of 25 sightings of bucks, 19 of those were unique individuals. Using this ratio, and multiplying it to the total number of deer sightings, we can estimate the population.

$$\frac{19\ individual\ bucks}{24\ buck\ sightings} = 0.79$$

$$0.79 * 85\ deer\ sightings = \mathbf{67\ deer}$$

12.9 Opinion Survey

The 2016 Opinion Survey Report divided Esquimalt into 6 zones based on relative deer density from the results of the survey (Nyberg, 2016). The ratings were:

- High: Parklands and Esquimalt Village
- Medium: Rockheights and Gorge
- Low: Selkirk and West Bay

Nyberg (2016) stated that "Deer or signs of deer were reported most frequently in the Parklands (100% of respondents), Esquimalt Village (90%), Rockheights (86%), and Gorge (85%) neighbourhoods; and least frequently in the Selkirk (52%) and West Bay (67%) neighbourhoods" (p.13).

He also states that "…the population density of deer appears to fall as one moves from west to east in Esquimalt, with substantially lower densities east of Tillicum Road and the portion of Lampson Street north of Esquimalt Road. The lowest density appears to be in the Selkirk area north-east of the intersection of Tillicum Road and Craigflower Road" (Nyberg, 2016, p.13).

And that "…more Parklands (27 percent) and Esquimalt Village (14 percent) respondents reported seeing deer on their properties 26-31 days/month than did the respondents from other neighbourhoods" (Nyberg, 2016, p.14).

The opinion survey results were very similar to the results from the data collected in this scientific survey. Taking the total number of deer sightings for each zone and dividing it by the length of its transect, I came up with a "density estimate". The only purpose of this density estimate calculation was to compare the densities of each zone relevant to each other. It does not represent the actual density.

Zone	Rockheights	Esquimalt Village	Parklands	Gorge	Selkirk	West Bay
Deer Sighted	16	26	19	0	1	2
Length of transect (km)	16.8	15.7	4.7	7.6	2.7	11.5
"Density"	**0.95**	**1.66**	**4.04**	**0**	**0.37**	**0.17**

Table 10. Calculation of "density" of each zone relative to each other

Relative to each other, the results from this survey placed the zones into the categories:

- High: Parklands
- Medium: Rockheights, Esquimalt Village
- Low: Gorge, Selkirk, West Bay

"Survey results indicated that deer or their sign have been observed at one time or another on 17 of every 20 properties in Esquimalt that hold residences with outside entrances. West Bay and Selkirk neighbourhoods have experienced substantially lower levels of deer use than the rest of the Township. This is probably because deer movement into those neighbourhoods is restricted somewhat by barriers such as the busy streets (Lampson and Tillicum) forming their western borders and the water to the north and south; and by the unfavorable habitat associated with the high proportion of industrial and commercial properties in the West Bay area" (Nyberg, 2016, p.26).

13 DISCUSSION

13.1 Department of National Defence 2017 Fall Survey

DND's land is substantially greener than the rest of Esquimalt, which may be a factor in encouraging more "wild" or "skittish" deer behaviour than in residential areas. This difference in habitat statistically permits an adaption to the survey techniques and still allows them to be comparable, especially since deer visibility is much higher in the DND lands. Another major difference is that DND does not permit dogs on their lands.

DND concluded that they had 41 deer/km^2 density over their 1.59 km^2 property (Prentiss, 2017). Refer to Appendix C for details. In the photos in their report, I recognized three individual deer from my survey (Slingshot, Nubs, and Friendly Nubs). This provides evidence that deer do migrate between DND lands and the Township of Esquimalt.

Unfortunately, there were some restrictions that prevented coordinating more details of our surveys. While this survey began at dawn, the DND was limited to beginning their surveys at 8:00 am. In addition, I requested that the DND take photos of every deer sighted in order to conduct a mark recapture study, but due to time constraints on the DND this wasn't possible. However, we managed to have several meetings throughout the project, and provided each other with our project updates.

Lorraine Crinkley previously worked on the initial deer survey design for the DND in Winter 2016. Ms. Crinkley now works at the Graving Docks, and potentially was going to help conduct deer surveys at the Graving Docks at the same time as our surveys. This fell through, but should be looked into again if this survey continues on for another year or more.

13.2 Sampling

- Driving at the aimed speed of 15 km/hr was often unsafe to do, especially on busy roads. Part of the reason for this was because surveys were conducted at dawn and dusk, which happen to be around rush hour at this time of year. Instead, the slowest speed possible which was still safe was driven. This varied among roads, but an attempt to remain consistent was made throughout the study.

- Daylight savings time happened mid way through the survey, which affected our survey time in correlation to rush hour.

- There were many dogs both on and off leash at all sites. This creates potential for deer-dog conflict. It is believed that deer recognize all dogs as wolves, or predators. While a normal response for a deer would be to run ("flight"), urban deer may be recognizing that these "urban wolves" are bound by their leashes, so the deer are bolder and instead respond with a "fight" response (Gates, pers. comm., 2017).

- At both Macaulay Point Park and Gorge Park, we regularly heard a very high pitch continuous sound. Esquimalt staff is unaware of any kind of noise deterrent being used there. However, this should be investigated further to see if it could potentially be a sound deterrent for wildlife.

- There were numerous signs of deer at Macaulay Point Park and Saxe Point Park, even though no deer were sighted there during the survey. This included wildlife trails and tracks. The golf course also had many wildlife trails and signs of deer.

- The golf course could not be sampled in reverse, as it would have disrupted the golfers too much.

- Lighting was an issue for taking photos before sunrise and after sunset that were high enough quality for photo identification.

13.3 Citizen Photos

In addition to the population estimate survey, Esquimalt residents were asked to send in their photos of deer. The idea was that as many individual deer would be identified and added to the photo identification catalogue, to provide a minimum count of deer. It also might give an idea of the range of some individual deer, especially those who were "recaptured" multiple times.

Refer to Appendix H for the advertisement requesting citizen involvement. It was posted on The Township of Esquimalt website and the Esquimalt Community Connection Facebook page. A $50 gift card was donated by the Cineplex Movie Theatre as a prize.

Unfortunately, most of the photos submitted were not of high enough quality to be able to identify the deer. In addition, time ran out for this lower priority item. The photos are still available if there is a desire to have them analyzed.

13.4 Changing Attitudes

Bryan Gates (pers. comm. 2017) believes, through his observations, that some urban deer in Greater Victoria are less healthy now than they were 2-5 years ago. A possible explanation is that many of the prime food sources in urban gardens have been consumed (other than fenced in areas or areas with fewer deer). Due to residents now desiring both deer-resistant and climate change-resistant gardens, they are planting different species, thus reducing urban deer food sources.

13.5 Camosun College Student Survey at Gorge Vale Golf Course

Some Camosun College Environmental Technology students, led by their instructor Annette Dehalt, surveyed the golf course on October 30, 2017. Essentially it was reconnaissance work for the more heavily wooded areas of the golf course. One student briefly sighted an unidentifiable deer. Simultaneously, we conducted our regular golf cart survey from 11:33 to 12:07. We did not see any deer. The course was much busier with golfers at this time of day compared to our usual dawn and dusk surveys.

13.6 Weather

Figure 27 shows the temperatures during the sample times (Environment Canada, 2017).

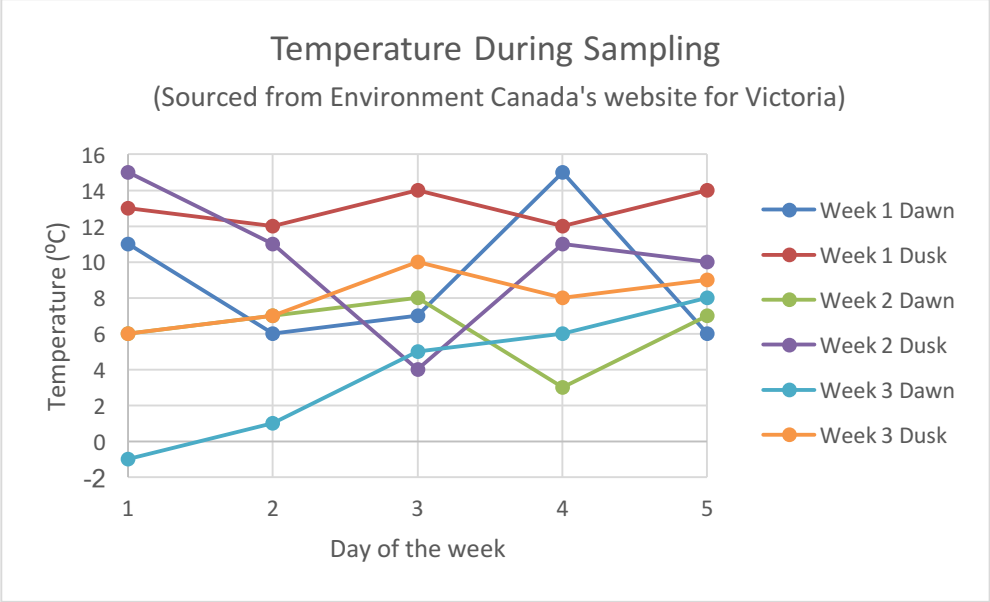

Figure 27. Graph of temperature during sampling

14 CONCLUSIONS

Four data analysis models were applied to the data to determine the population estimate of deer in Esquimalt. As shown in Figure 28, these population estimates ranged from 54 to 143 deer. The average of the four estimates is 100 deer. **Based on personal knowledge from field observations, I believe that 100 is a very reasonable population estimate of deer in Esquimalt.**

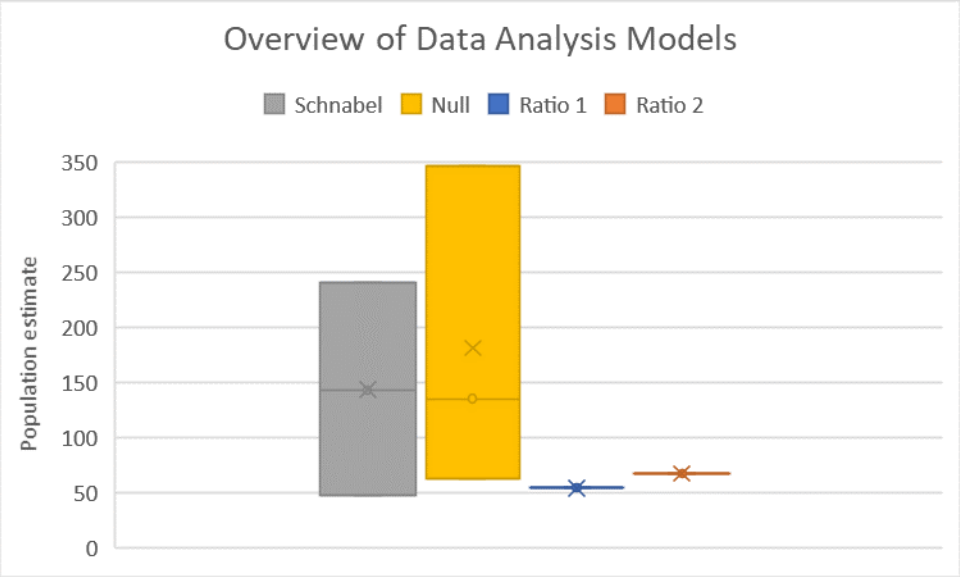

Figure 28. Graph of overview of data analysis models

In conclusion, the deer population in Esquimalt is estimated to be 100 deer, based on the average estimate of the four different analysis methods used in this study. Those independent estimates ranged from 54 to 143.

Relative to each other, Parklands and the Gorge Vale Golf Course have a high deer density; Rockheights and Esquimalt Village have a medium deer density; and Gorge, Selkirk, and West Bay have a low deer density.

15 RECOMMENDATIONS

- During the surveys, especially the driving surveys, it can be difficult for two people to complete all of the tasks. Ideally, a team of three is recommended.
- It is most ideal to survey the entire study site simultaneously, to reduce variables and potential double counting mobile deer. For example, an ideal situation would be to have five survey teams of three people, surveying one each of the five zones. This situation would have less sample days.
- The parks were not surveyed as in depth as the roads were. The use of transects, and/or a spotlight survey would be ideal.
- A better camera would be useful in order to capture the finer details for deer identification.
- A drone to survey the Golf Course should be explored.

- Using Artificial Intelligence to use facial recognition for the deer (especially does) should be explored.

- Increased sightings and increased unique individuals will more accurately enhance all data analysis models.

- Krebs (2014) stated that "The Fourier Series Estimator is a robust estimator that is sufficiently general to fit almost any type of line transect data. It is a good general purpose estimator and is strongly recommended by Bruham et al. (1980) as the best model available" (p.205). However, this is a very complicated statistical model, and so the simpler Hayne's Estimator is recommended instead. An average sighting angle of 32.7^{o} must be obtained in order to use this model (which was not the case with this study's data).

- Investigate the high pitch sound at Macaulay Point Park and Gorge Park.

- After each deer sighting, a 5-minute wait time before moving on is recommended. Often more deer accompanying the first deer sighted would come into view after waiting a little while. There is a delicate balance between waiting to see more deer, and staying on track of time on the survey, in order to stay in peak dawn/dusk hours.

It should be noted that some of the above recommendations would require an increased budget.

15.1 Next Steps

In order to identify population trends, multi-year surveying is required. The exact methods used here should be replicated in future years in order to compare the data over time. If possible, Esquimalt and the DND should coordinate their methodologies so that more details can be matched between surveys in order to make the data more compatible.

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17 APPENDICES

Appendix A: Esquimalt Neighbourhood Map from Opinion Survey Report

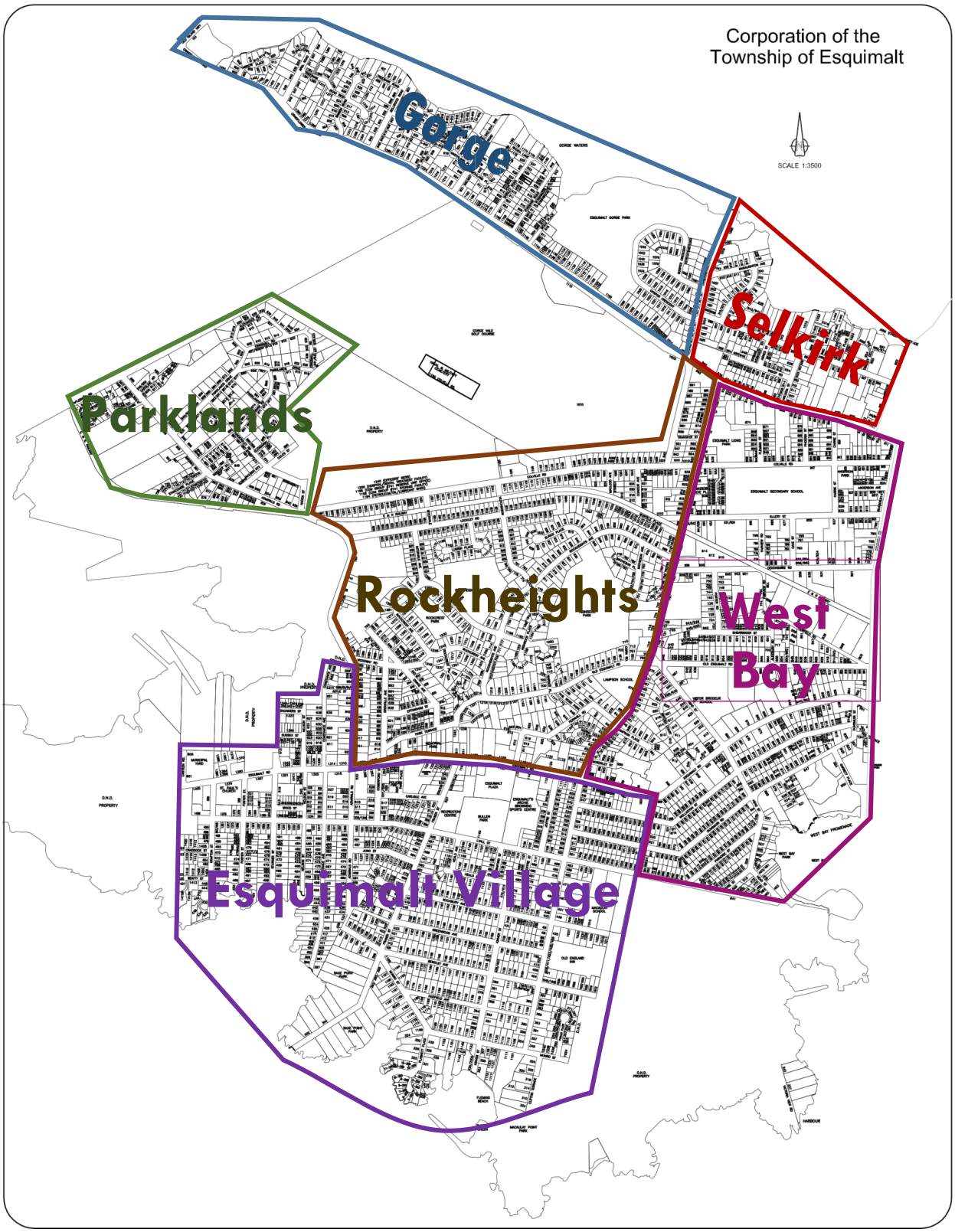
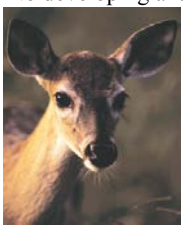


Figure 1. Neighbourhoods defined for this study.

Appendix B: DND's Field Guide for Gender/Age ID

Field Guide for Aging and Sexing Black Tailed Deer*

Age Class	General Description		
Fawn	• Still has spotted coat • Small, square body • Short neck, nose and forehead • Travels with mum, but also seen hiding alone	**MALE & FEMALE** 	
Yearling	• No spots • Small, square body • Short neck, nose and forehead	**MALE** • Head appears flatter • Presence of antler pedicles 	**FEMALE** • Head appears rounder • No developing antlers 
Mature	• Large rectangular body • Long neck, nose and forehead • Often has swaying back or sagging belly	**MALE** • Presence of antlers or pedicles • Head appears flatter 	**FEMALE** • No antlers or pedicles • Head appears rounder 

***Some Deer individuals pictured above are not specifically Black Tailed Deer species, but do exhibit the same identifying characteristics**

EQUIPMENT CHECKLIST

Please provide for yourself:	Will be provided for you:
• Suitable footwear for uneven, rocky terrain and possible wet conditions • Clothing suitable for both wet and dry weather and appropriate for bush whacking • Your DND ID • Water and snacks (optional)	• Clipboards, pens and field sheets • Site maps • Copies of this field guide • Binoculars • Spotlights • Head lamps • Cameras

OTHER NOTES

- Do not transverse any terrain if you do not feel safe doing so (document where necessary on field sheet and map)
- Each team member should attempt to sex each individual to ensure accuracy. If there is any ambiguity while sexing the deer, note the sex as unknown
- Remain a safe distance from deer at all times
- Make notes of any unusual observations or deer behavior such as distinguishing marks (eg. broken antler) or signs of declining health (eg. obvious injuries, animal allows you to approach, etc)
- Document any possible double counting
- It is normal for fawns to be left alone by their mothers for hours at a time – they are not necessarily abandoned
- If PMQ residents question you about your presence, advise them about the deer surveys and offer your ID. If they continue to have concerns refer them to the general inquiries number below.
- If you encounter any loose domestic pets in the PMQ areas that hinder deer sampling call the CRD number below
- Have fun!

Lorraine Crinkley February 2016

Appendix C: DND Fall 2017 Survey Results

Statistical Analysis

Table 11. Statistical analysis of census results

	Dockyard	Signal Hill	Yarrows and Naden	North Naden	Work Point	Total
Area (km²)	0.21	0.26	0.27	0.25	0.6	**1.59**
# of Deer Observed	39	30	38	17	56	**180**
#of Deer Identified	38	30	38	17	56	**179**
Average # of Deer Observed	12.9	10	12.6	5.7	18.7	**59.9**
Estimated Population Density (deer/km²)	61.43	38.46	46.67	22.8	31.17	**40.11 (40)**
Does per Buck	4.1	1.9	3.1	1.2	1.2	**1.9**
Yearlings per Doe	1.2	0.2	1.1	1	0.9	**0.8**

Discussion

Comparative Analysis

The estimated population density (deer/km²) for Spring 2016 was 42 deer deer/km², 43 deer/km² for Winter 2016, and 41 deer/km² for this survey (Table 12). This shows that the deer population has slightly decreased from what the population was in 2016 which could indicate that herd health is declining or the population is self-correcting for an exceeded biological carrying capacity. The estimated population density for the base is high, however, the effects of density-dependence eventually minimizes food sources leading to emigration of the herd or lowered reproductive rates (Bender, Lewis, & Anderson, 2004). This would mean that yearling recruitment rates would drop and slowly lessen the population.

From the survey done this year, the yearling to doe ratio is decreasing as it was 0.8:1 for this survey, compared to 1.37:1 last fall. From observing the herds over three weeks, they do not look to be in bad health, none of the deer were malnourished or sickly. The males were large and bulky with big antler racks, meaning they had enough energy to put into secondary sexual characteristics. This leads to the conclusion that due to over-crowding the deer population had less fawns.

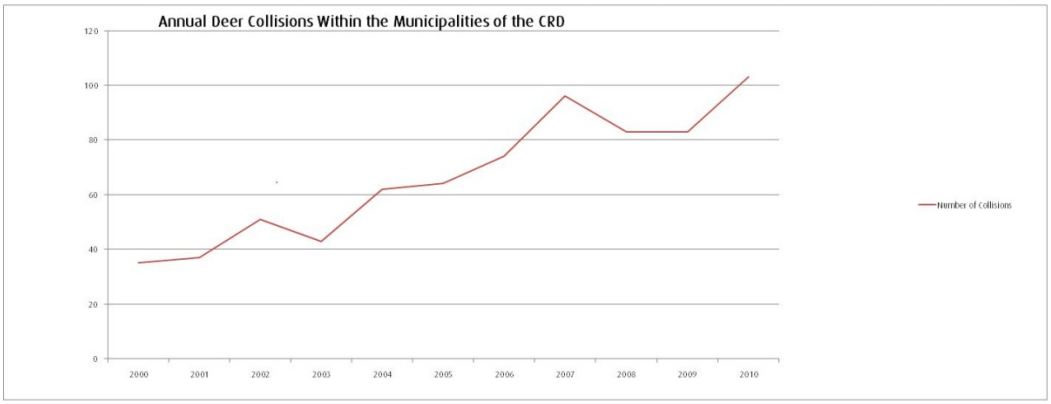
Table 12. Total average results comparison from the Feb 2016, the Nov 2016, and the Oct 2017.

	Feb/Mar 2016	Nov 2016	Oct/Nov 2017
# of Deer Observed	**167**	**196**	**180**
# of Deer Identified	**115**	**172**	**179**
Estimated Population Density (deer/km²)	**41.42 (42)**	**42.82 (43)**	**40.11 (41)**
Does per buck	**1.9**	**1.7**	**1.9**
Yearlings per doe	**1.92**	**1.37**	**0.8**

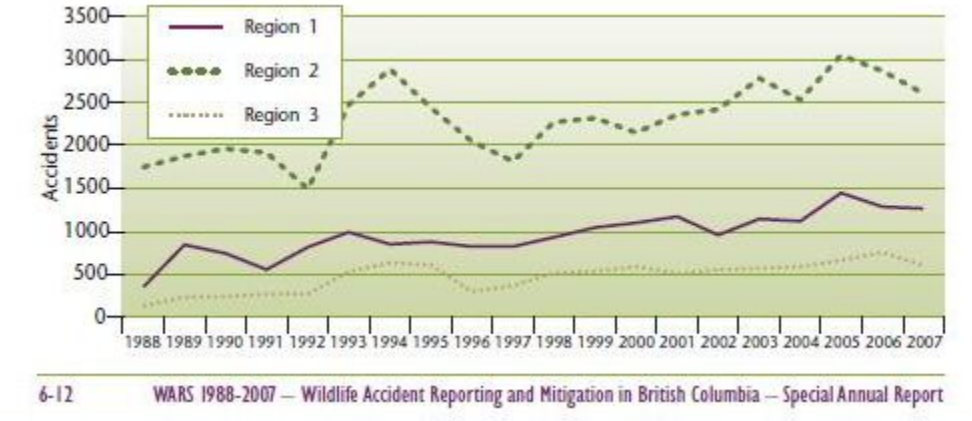
Appendix D: ICBC Deer Collision Statistics

APPENDIX B – Deer Collision Statistics

Annual Deer Collisions Within the Municipalities of the CRD												
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Number of Collisions	35	37	51	43	62	64	74	96	83	83	103	731



Regional Comparison of Total Annual Deer Accidents



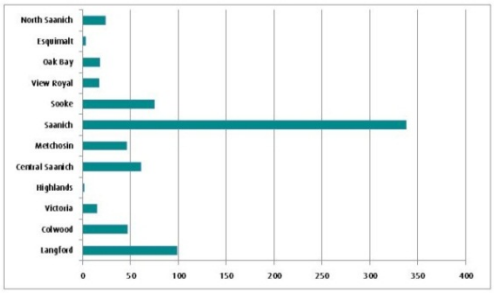
Region 1: Vancouver Island

Region 2: Lower Mainland

Region 3: Thompson River

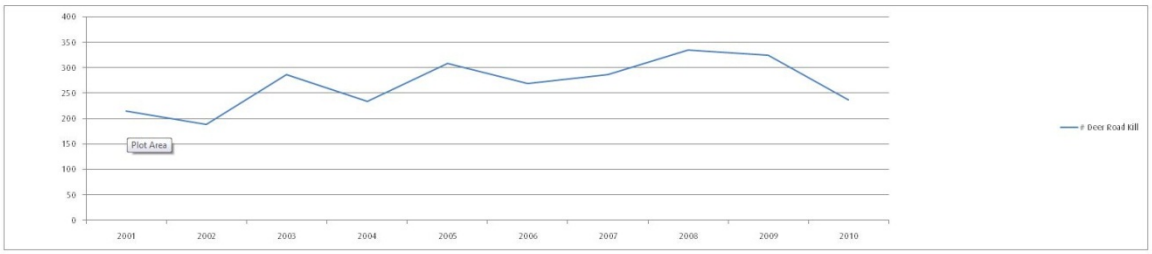
Monthly Deer Accidents on Vancouver Island

Deer Collisions 2000-2010 By Municipality Reported to ICBC												
Langford	Colwood	Victoria	Highlands	Central Saanich	Metchosin	Saanich	Sooke	View Royal	Oak Bay	Esquimalt	North Saanich	Total
99	47	15	2	61	46	338	75	17	18	3	24	**745**

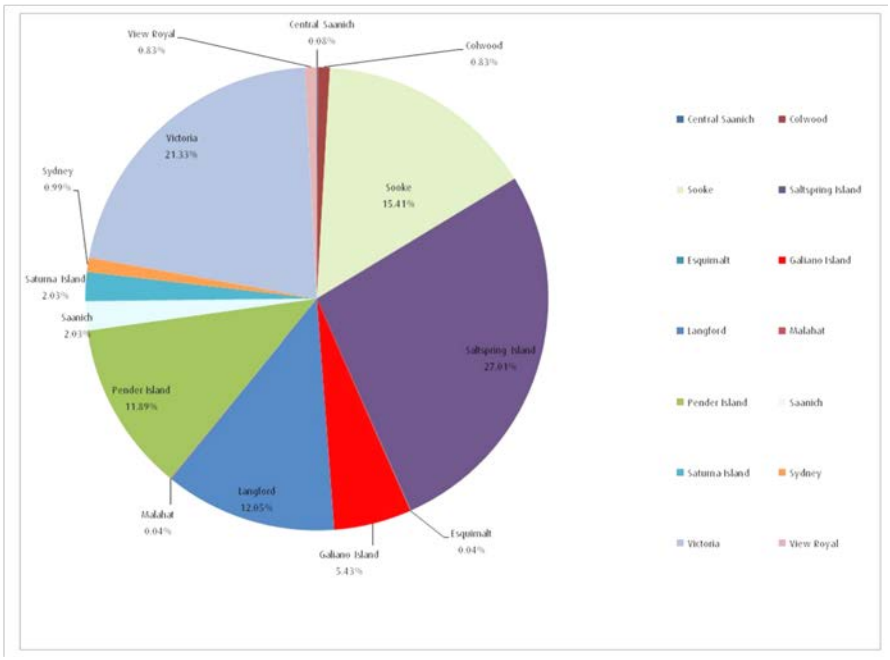


ICBC Animal-related Motor Vehicle Accident Claims in British Columbia (1997 to 2002)										
Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Claims Cost (in millions $)	$15.8	$18.4	$19.1	$21.6	$25.2	$29.1	$27.7	$25.5	$31.4	$34.3	$30.8

Total Annual Deer Fatalities From Motor Vehicles in the CRD from 2001-2010										
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
# Recorded Deaths	214	189	287	234	309	269	286	335	324	236



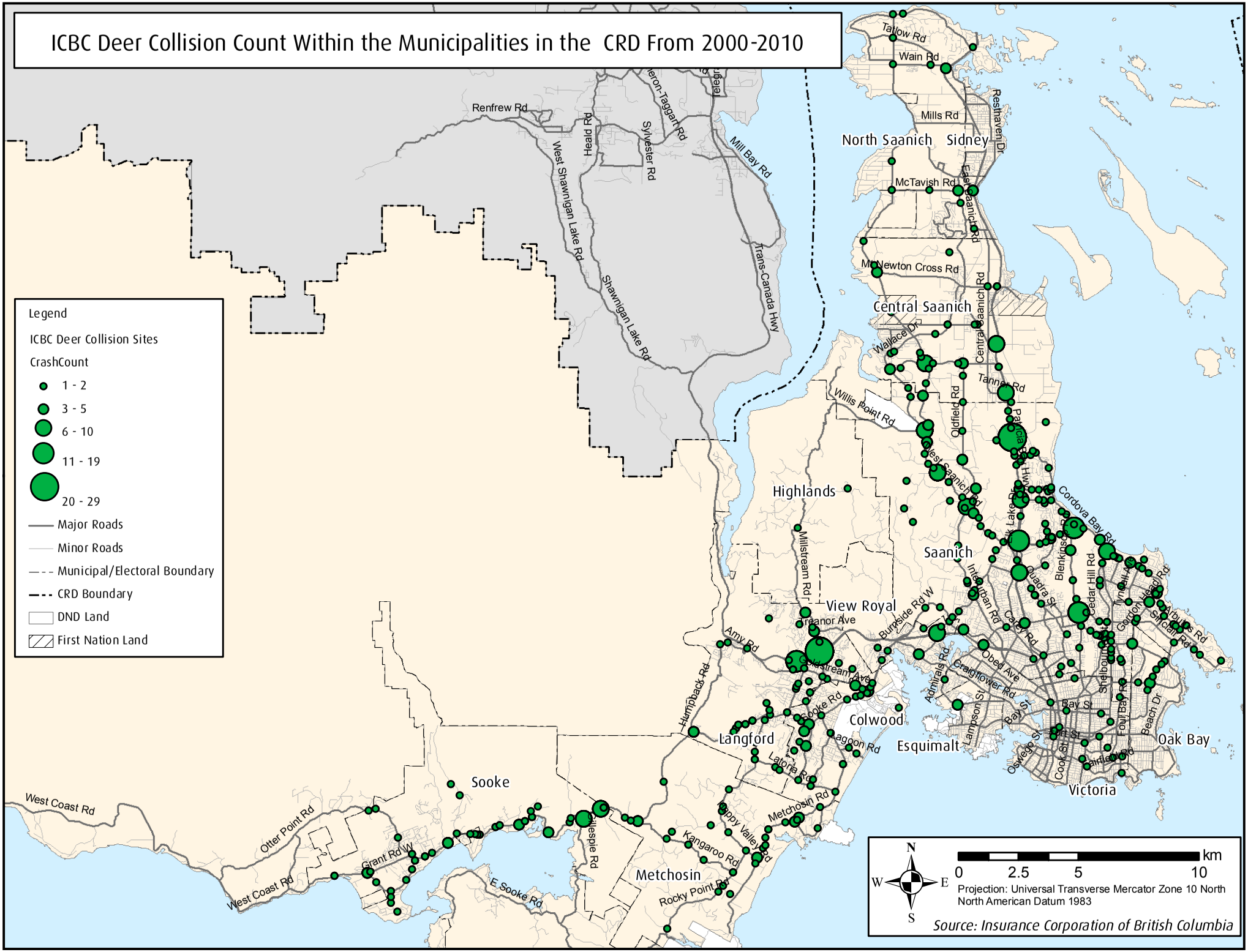
Recorded Road Kill in the CRD By MoT From 2001-2010													
Central Saanich	Colwood	Sooke	Saltspring Island	Esquimalt	Galiano Island	Langford	Malahat	Pender Island	Saanich	Saturna Island	Sydney	Victoria	View Royal
2	20	372	652	1	131	291	1	287	49	49	24	515	20



Accident Clean-Up		
Animal Size	**Animal Example**	**Cost Estimate**
Small	fox, porcupine, skunk	$25
Medium	bear,cougar,**deer**, moutain sheep	$100
Large	caribou,elk,moose	$350

Deer Collision Severity to Humans within British Columbia from 2000-2007				
Year	**Fatal**	**Injury**	**Property Damage Only**	**Total**
2000	0	198	617	815
2001	3	263	1054	1319
2002	2	293	1212	1507
2003	4	286	1392	1682
2004	6	267	1312	1585
2005	1	302	1466	1769
2006	3	304	1276	1583
2007	3	272	1103	1378
Total	21	2185	9432	11639

Deer Collision Severity to Humans within the CRD from 2006-2010				
Year	**Fatal**	**Injury**	**Property Damage Only**	**Total**
2006-2010(Average)	0	10(8 injured Victims)	245	255


ICBC Deer Collision Count Within the Municipalities in the CRD From 2000-2010
Legend
ICBC Deer Collision Sites
CrashCount
1 - 2
3 - 5
6 - 10
11 - 19
20 - 29
Major Roads
Minor Roads
Municipal/Electoral Boundary
CRD Boundary
DND Land
First Nation Land
North Saanich
Sidney
Central Saanich
Highlands
Saanich
View Royal
Colwood
Langford
Esquimalt
Oak Bay
Victoria
Sooke
Metchosin
Tallow Rd
Wain Rd
Mills Rd
McTavish Rd
Mt Newton Cross Rd
Wallace Dr
Tanner Rd
Willis Point Rd
West Saanich Rd
Cordova Bay Rd
Millstream Rd
Trans-Canada Hwy
Island Hwy
Quadra St
Cedar Hill Rd
Gordon Head Rd
Shelbourne St
Admirals Rd
Craigflower Rd
Obed Ave
Bay St
Fort St
Foul Bay Rd
Beach Dr
Oswego St
Cook St
Fairfield Rd
Burnside Rd W
Tillicum Rd
Tolmie Ave
Interurban Rd
Carey Rd
Treanor Ave
Amy Rd
Goldstream Ave
Sooke Rd
Lagoon Rd
Latoria Rd
Humpback Rd
Metchosin Rd
Happy Valley Rd
Kangaroo Rd
Rocky Point Rd
Gillespie Rd
E Sooke Rd
Grant Rd W
Otter Point Rd
West Coast Rd
Renfrew Rd
Veron-Taggart Rd
Sylvester Rd
Mill Bay Rd
West Shawnigan Lake Rd
Shawnigan Lake Rd
Resthaven Dr
East Saanich Rd
Central Saanich Rd
Oldfield Rd
Patricia Bay Hwy
Lake Rd
Blenkinsop Rd
Tillicum Rd
Gordon Head Rd
N
W
E
S
km
0
2.5
5
10
Projection: Universal Transverse Mercator Zone 10 North
North American Datum 1983
Source: Insurance Corporation of British Columbia

Appendix E: Field Work Schedule

Field Work Schedule				
Date	**Dawn/Dusk**	**Road Zone**	**Parks**	**Forward/Reverse Route**
Week 1				
Mon Oct. 23	Dawn	Rockheights	Highrock	Forward
	Dusk	Rockheights	Highrock	Forward
Tues Oct. 24	Dawn	Esquimalt Village	Macaulay & Saxe Point	Forward
	Dusk	Esquimalt Village	Macaulay & Saxe Point	Forward
Wed Oct. 25	Dawn	West Bay	n/a	Forward
	Dusk	West Bay	n/a	Forward
Thurs Oct. 26	Dawn	Selkirk / Parklands / Gorge	Gorge	Forward
	Dusk	Selkirk / Parklands / Gorge	Gorge	Forward
Fri Oct. 27	Dawn	Golf Course	n/a	Forward
	Dusk	Golf Course	n/a	Forward
Week 2				
Mon Oct. 30	Dawn	Rockheights	Highrock	Forward
	Dusk	Rockheights	Highrock	Reverse
Tues Oct. 31	Dawn	Selkirk / West Bay	n/a	Forward
	Dusk	Selkirk / West Bay	n/a	Reverse
Wed Nov. 1	Dawn	Esquimalt Village	Macaulay & Saxe Point	Forward
	Dusk	Esquimalt Village	Macaulay & Saxe Point	Reverse
Thurs Nov. 2	Dawn	Parklands / Gorge	Gorge	Forward
	Dusk	Parklands / Gorge	Gorge	Reverse
Fri Nov. 3	Dawn	Golf Course – CLOSED DUE TO SNOW	n/a	n/a
	Dusk	Golf Course	n/a	Forward
Week 3				
Mon Nov. 6	Dawn	Rockheights	Highrock	Reverse
	Dusk	Rockheights	Highrock	Reverse
Tues Nov. 7	Dawn	Esquimalt Village	Macaulay & Saxe Point	Reverse
	Dusk	Esquimalt Village	Macaulay & Saxe Point	Reverse
Wed Nov. 8	Dawn	Parklands / Gorge	Gorge	Reverse
	Dusk	Parklands / Gorge	Gorge	Reverse
Thurs Nov. 9	Dawn	Selkirk / West Bay	n/a	Reverse
	Dusk	Selkirk / West Bay	n/a	Reverse
Fri Nov. 10	Dawn	Golf Course	n/a	Forward
	Dusk	Golf Course	n/a	Forward
Make Up				
Tues Nov. 14	Dawn	Golf Course	n/a	Forward
	Dusk	Golf Course	n/a	Forward

Dawn surveys will be start 20 mins before sunrise, and go until completion.
Dusk surveys will end 20 mins after sunset, and so will be timed to start depending on the average time to complete the zone.

Date	**Sunrise**	**Sunset**
Week 1		
Mon Oct. 23	7:46 am	6:08 pm
Tues Oct. 24	7:47	6:06
Wed Oct. 25	7:49	6:05
Thurs Oct. 26	7:50	6:03
Fri Oct. 27	7:52	6:01
Week 2		
Mon Oct. 30	7:56	5:56
Tues Oct. 31	7:58	5:55
Wed Nov. 1	8:00	5:53
Thurs Nov. 2	8:01	5:51
Fri Nov. 3	8:03	5:50
Week 3		
Mon Nov. 6 (daylight savings)	7:07	4:45
Tues Nov. 7	7:09	4:45
Wed Nov. 8	7:10	4:42
Thurs Nov. 9	7:12	4:41
Fri Nov. 10	7:14	4:40
Make Up		
Tues Nov. 14	7:20	4:35

Appendix F: Data Sheet

2017 Deer Population Estimate Survey in Esquimalt, BC

Zone	Date	Surveyors	Weather (Environment Canada)	Total Start/End Time	Road Start/End Time	Park Start/End Time	Route Forward or Reverse	Total Length Driven (km)

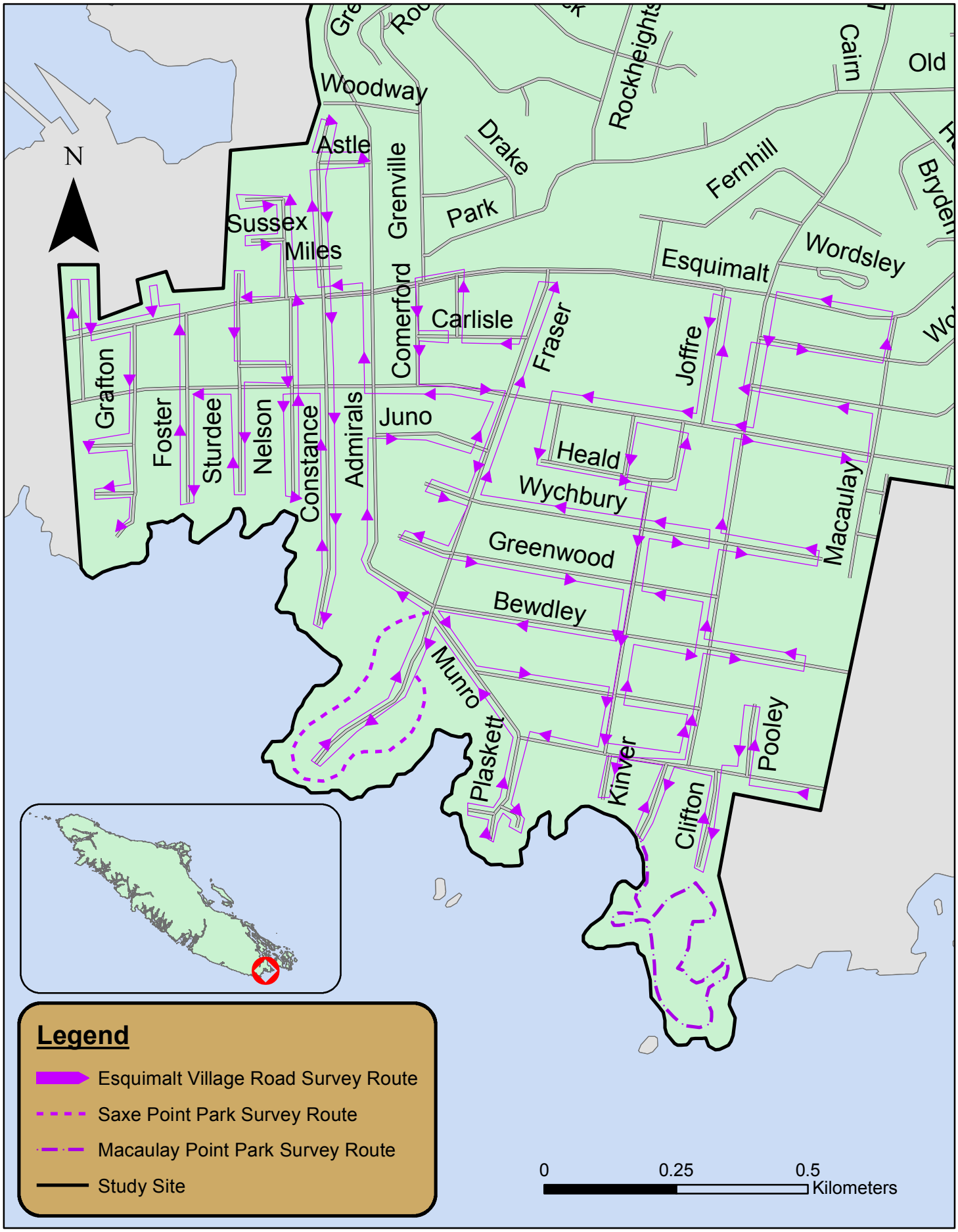
Road or Park Zone	Time	Number of Deer	GPS Coordinates	Distance (m) and Angle	Buck, Doe, Yearling (M/F), or Fawn	Photo Numbers	Behaviour	Notes

Notes

*Please fill out one line for each deer sighted. Ditto marks (“) should be used to indicate similar data within the same group of deer on the same sighting.

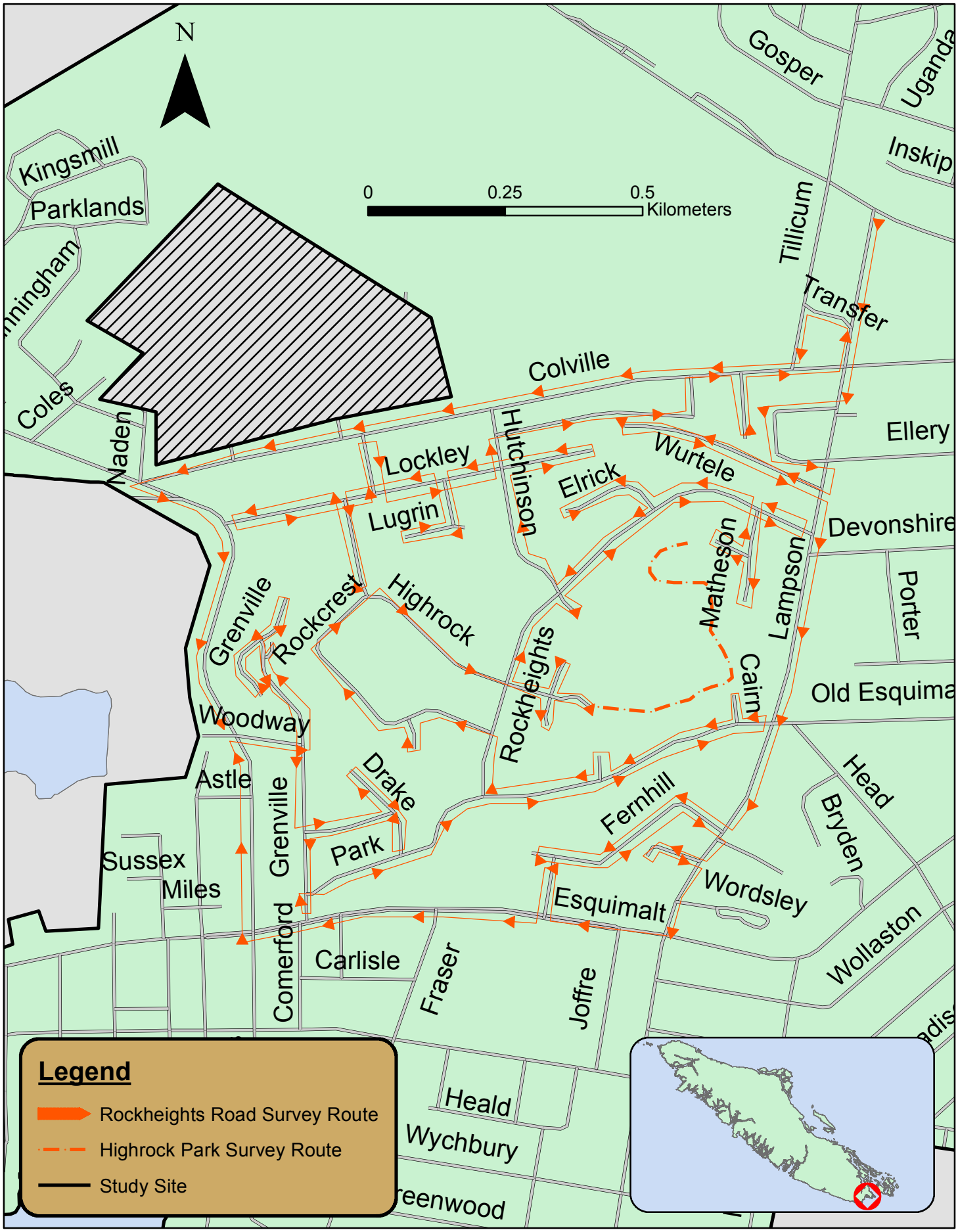
Appendix G: ArcGIS Maps of Enlarged Survey Routes For Each Zone

Esquimalt Village Survey Route



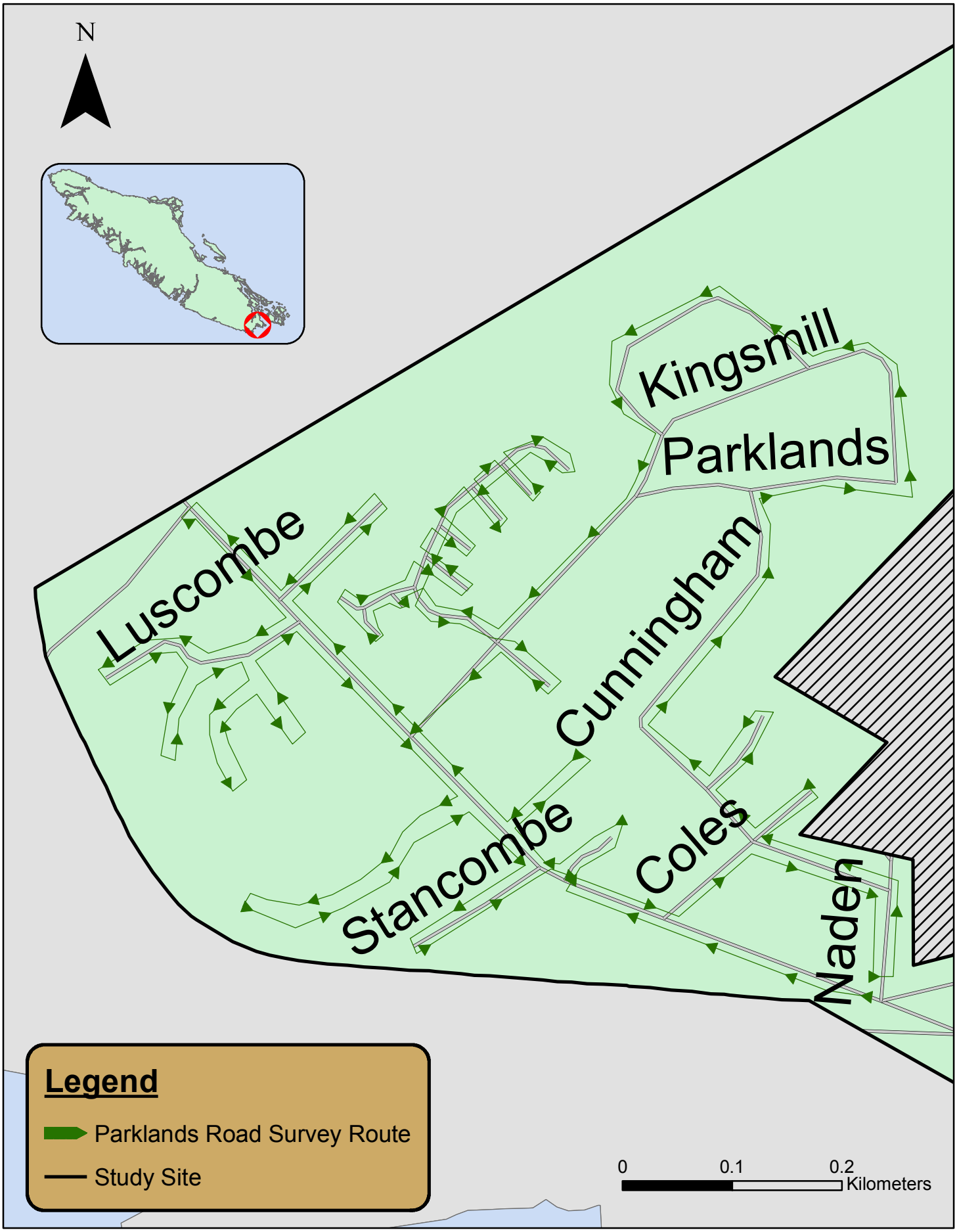
Authors: Kevin Pons & Megan Sakuma
Date: December 6, 2017
Projection: NAD 1983
Data source: ESRI, Kevin Pons, Megan Sakuma

Rockheights Survey Route



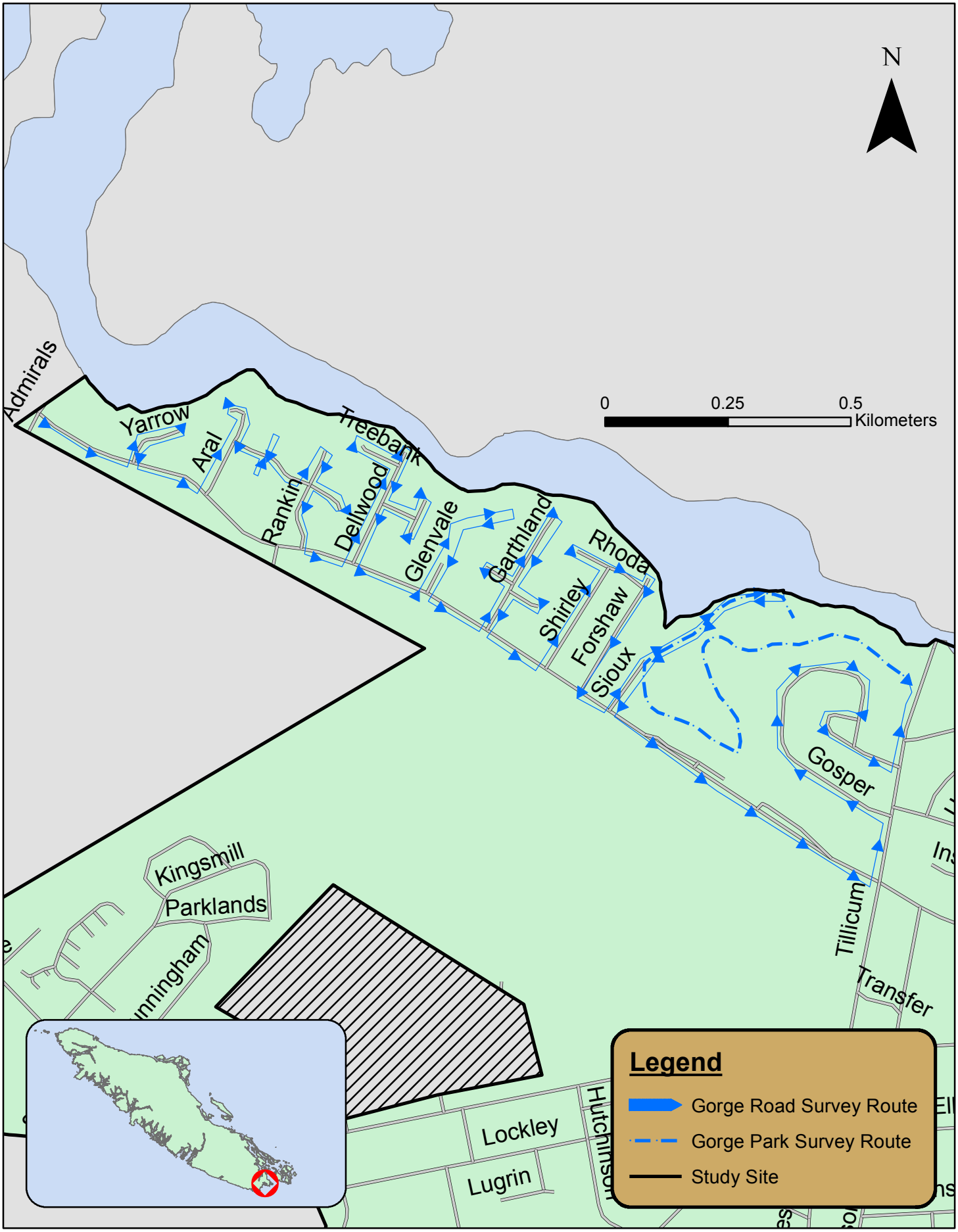
Authors: Kevin Pons & Megan Sakuma
Date: December 6, 2017
Projection: NAD 1983
Data source: ESRI, Kevin Pons, Megan Sakuma

Parklands Survey Route



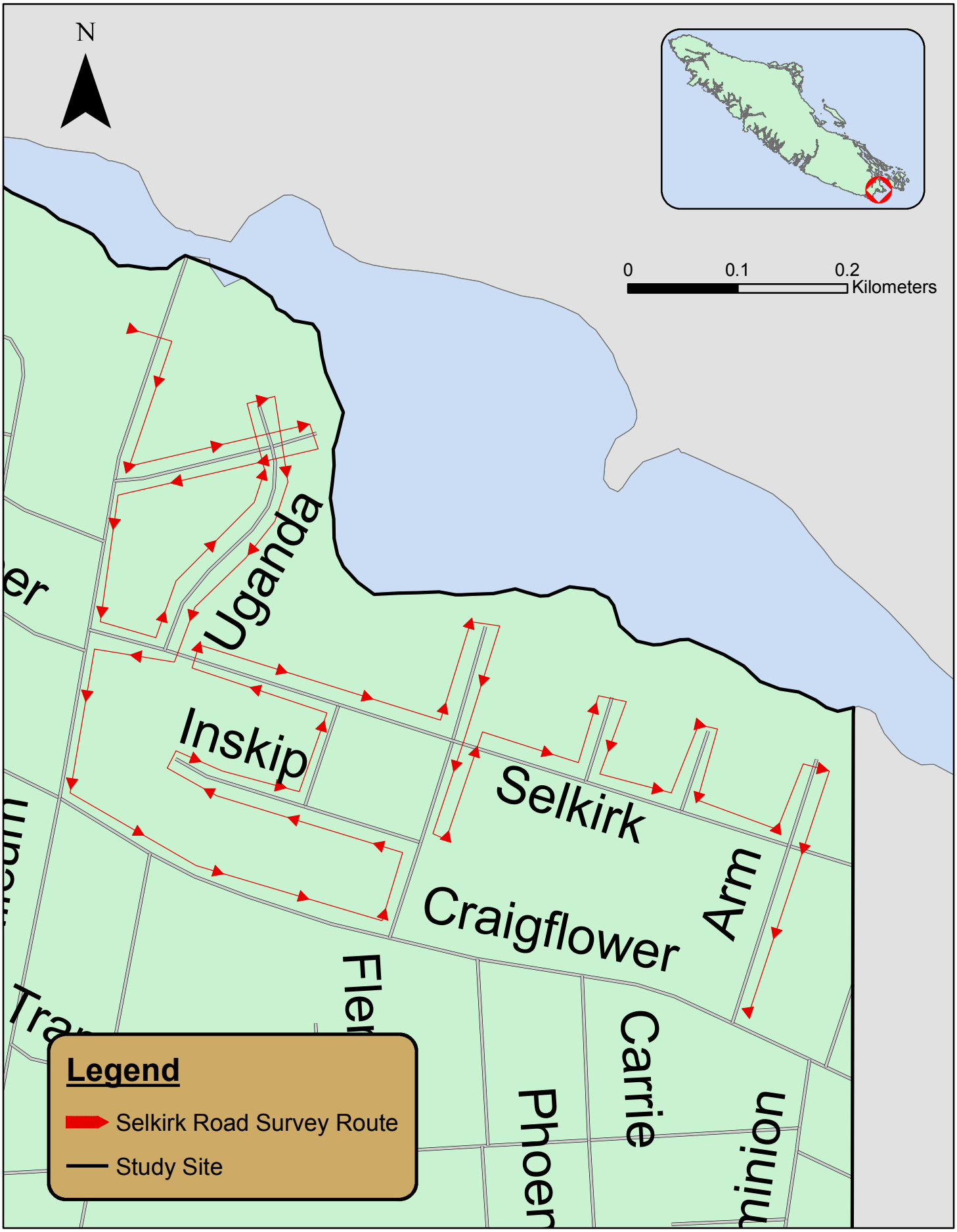
Authors: Kevin Pons & Megan Sakuma
Date: December 6, 2017
Projection: NAD 1983
Data source: ESRI, Kevin Pons, Megan Sakuma

Gorge Survey Route



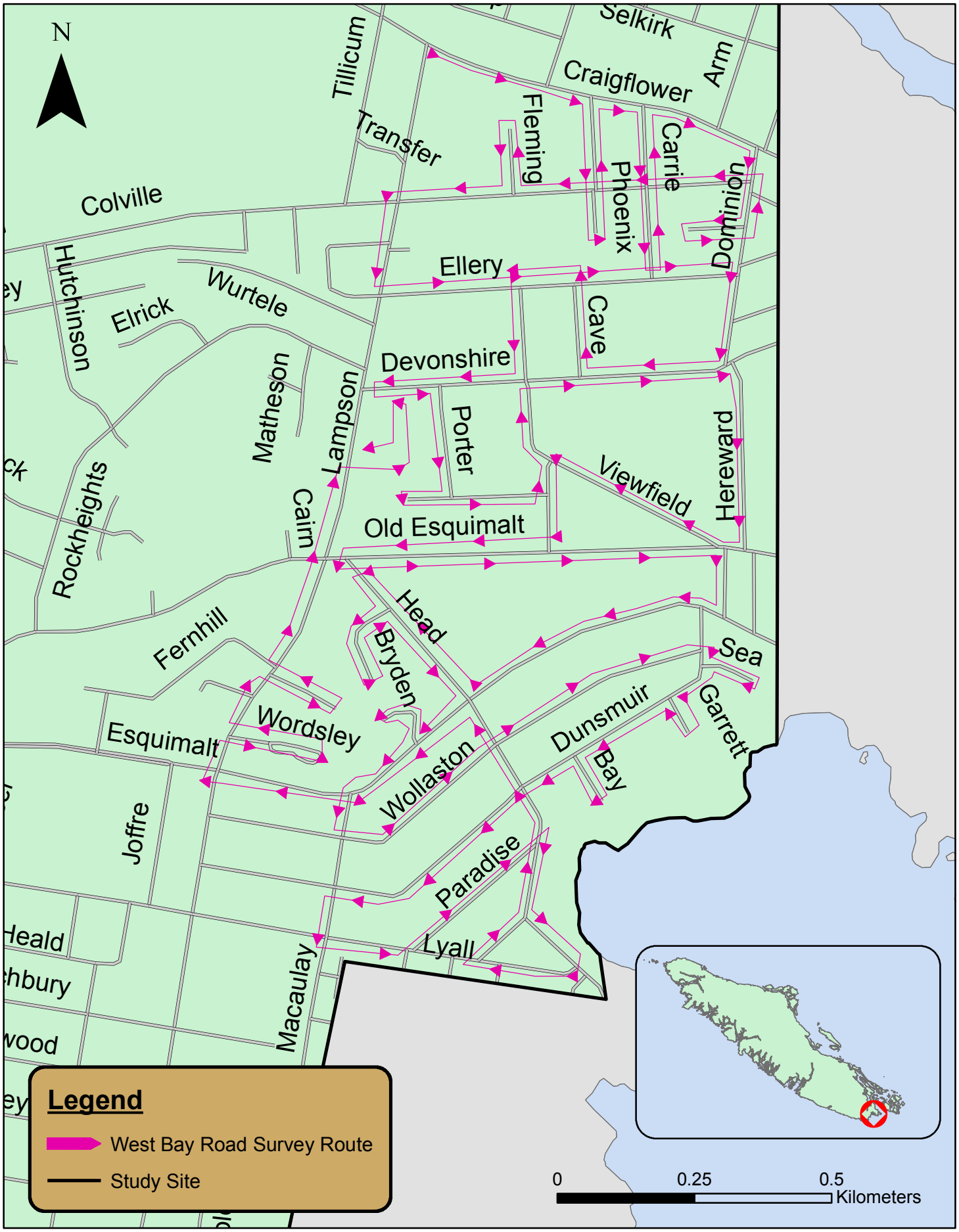
Authors: Kevin Pons & Megan Sakuma
Date: December 6, 2017
Projection: NAD 1983
Data source: ESRI, Kevin Pons, Megan Sakuma

Selkirk Survey Route



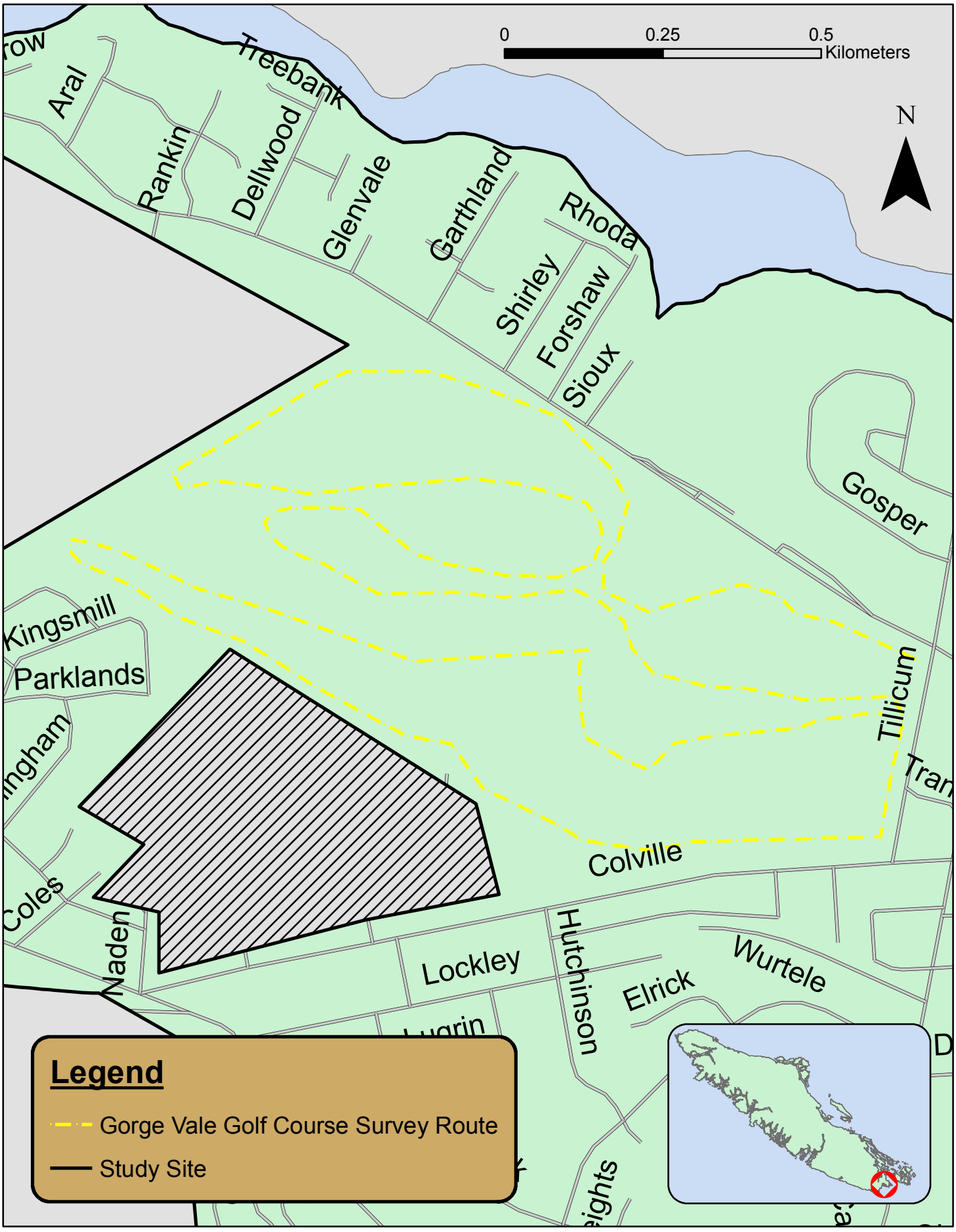
Authors: Kevin Pons & Megan Sakuma
Date: December 6, 2017
Projection: NAD 1983
Data source: ESRI, Kevin Pons, Megan Sakuma

West Bay Survey Route



Authors: Kevin Pons & Megan Sakuma
Date: December 6, 2017
Projection: NAD 1983
Data source: ESRI, Kevin Pons, Megan Sakuma

Gorge Vale Golf Course Survey Route



Authors: Kevin Pons & Megan Sakuma
Date: December 6, 2017
Projection: NAD 1983
Data source: ESRI, Kevin Pons, Megan Sakuma

Appendix H: Advertisement Poster for Photos

WANTED: DEER PHOTOS!

The Township of Esquimalt and the Urban Wildlife Stewardship Society are conducting a population estimate survey of deer in Esquimalt. We will be surveying and photographing deer this Fall, 2017.

We need your help! In order to identify as many unique individuals as possible, we want to add your recent and future photos of deer seen within Esquimalt to our photo ID catalogue.

Unique facial marking

Damaged ear

Almost any close photograph will help, but here are the IDEAL CRITERIA:

1. **High quality photo**
2. **Face and antlers facing forwards**
3. **Ears flared outwards facing forwards**
4. **Full body in the image**
5. **Multiple angles**
6. **The location, time, and date observed**

*Each photo submitted will enter your name into a draw for a **prize**!*

Please email your photos to: Project Manager, Megan Sakuma

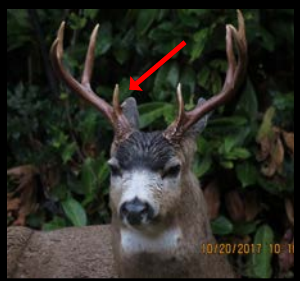
msakuma@shaw.ca

Appendix I: Photo Identification Catalogue

Buck Inventory in Esquimalt

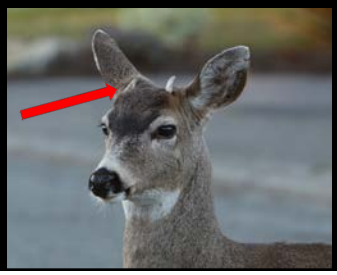
Fall 2017

MA (Male Adult) 01: “Right 2-tine”



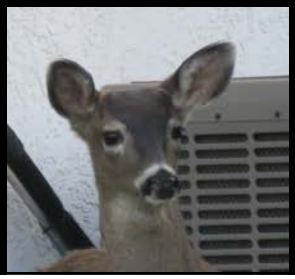
MA 02: “Blur Buck”

MA 03: “Lady”



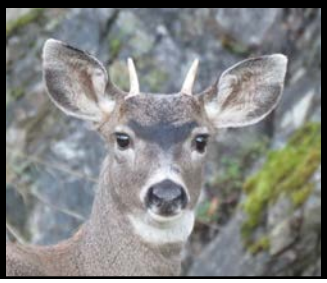
MA 04: “Tooth”

MA 05: “Mama’s Boy”

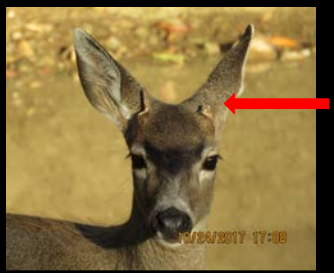


MA 06: “Narrow Minded”

MA 07: “Young Stud”



MA 08: “Lil Rascal”



MA 9: “Replacement”

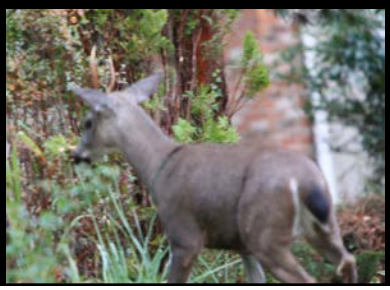
MA 10: “2-3”

MA 11: “Slingshot”

MA 12: “Old Timer”

MA 13: “Long Butt”

MA 14: “Necklace”



MA 15: “Trampoline”

MA 16: “Bully”

MA 17: “Halfer”

MA 18: “Young Blur Buck 1”

MA 19: “Young Blur Buck 2”